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Professor William Henry Pickering
1858-1938
AN APPRECIATION

By E. P. MARTZ, Jr.

On January sixteenth, amid the tropical beauty of the island of Jamaica in the British West Indies, there passed away, in his eightieth year, one of the few remaining astronomers of the school of Flammarion, Schiaparelli, Lowell.

William Henry Pickering was born in Boston just before the Civil War, on February 15, 1858. He came of a family as famous in the state of Massachusetts and the history of New England as the Cabots and the Lowells. After attending school and college in Boston and Cambridge he received the Bachelor of Science degree from the Massachusetts Institute of Technology in 1879; and continued to teach physics there until 1883. Soon after his graduation he was also called to nearby Harvard, to teach astronomy, by his brother Professor Edward C. Pickering, Director of Harvard College Observatory from 1876 to 1920. The young William H. Pickering had his first astronomical experience, though, during the total solar eclipse of 1878, when he measured the radial polarization of the corona. In 1887 he was made Assistant Professor of Astronomy at Harvard Observatory, though much of his future work was to be done away from Cambridge. Throughout this early period, and in later life, he was an ardent amateur photographer, and did much to aid in the development of that science, particularly in its application to astronomy. His photographs of a horse in motion, taken in rapid succession, were among the first attempts of their kind in this country at motion picture photography. Professor Pickering made some of the first successful photographs of the Great Nebula in Orion, with a small camera, using dry plates, attached to a telescope. On the basis of this successful experiment, William H. Pickering suggested to his brother Edward the large scale application of photography to a photographic survey of the sky. This was acted upon and resulted in the great Harvard survey of the entire sky, which now contains over 400,000 plates taken at Harvard Stations from both hemispheres during the last fifty years or so. In addition to the photographic work, W. H. Pickering also undertook numerous photometric investigations about this time, founding standards and comparisons upon which much of his brother's stellar photometry was based.

In 1888, with the 13-inch Boyden refractor, he undertook some of the earliest photographs of the planet Mars, using blue-sensitive plates.

This work seems to have determined much of his future trend; for, in 1890, he began the first of his many programs of visual observations and drawings of the planet with the famous 15-inch refractor, and the 12-inch Gerrish Polar Telescope in Cambridge. It was then that he made his primary experiments with the applications of color sensitivity of the eye to analyses of observations of "The Planet"; and then that he first saw the so-called "canali" of Mars, discovered only a few years before by the great Italian observer, Schiaparelli.

Following the observation of an eclipse of the sun in 1889, the two Pickerings made tests of a number of places, including Pike's Peak in Colorado, in the hope of finding a good spot for a branch station of the Harvard Observatory, which would be farther south and with better climatic conditions than Cambridge had. The peak of Mount Wilson in Southern California was decided upon; and, under the superintendence of W. H. Pickering, the 13-inch Boyden telescope was mounted there, and work in astronomical photography instituted. The Mount Wilson station, and later ones in Peru and Jamaica, were financed principally by the $240,000 Boyden Fund, left to Harvard Observatory for the establishment of an astronomical observatory at a high altitude. Further photographs of Mars were also made by Professor Pickering from this station, as well as a beginning of the development of the Harvard photographic surveys of the sky. A private observatory was also established on nearby Mount Lowe, about this time, with which W. H. Pickering was connected. The instrument was a visual refractor of 18-inches aperture, but apparently of "doubtful" origin. It was not until years later that the late Dr. George Ellery Hale again tested the Mount Wilson site, found it good, and established the present-day world's-largest observatory there. It is of interest, to those who have visited Mount Wilson, that the exact site of the 13-inch Harvard refractor and station in 1889-90, was about fifty feet *above* the level of the present-day parking lot on the hotel grounds. This space was leveled off, some years ago, to make room for visiting automobiles. Photographs of the old Harvard Station can still be seen in the little kitchen-house, between the 100-inch and 60-inch reflector domes, where the observers enjoy their "midnight lunch."

As it was desired to establish a station still farther south than Mount Wilson, W. H. Pickering, in 1891, with the aid of A. E. Douglass, and others, set up the Boyden telescope in the mountains above Arequipa, Peru, in South America. Photographs of the southern sky were made; and in 1892 visual observations of Mars and of Jupiter's Third Satellite, Ganymede, were undertaken. It was then that Pickering and Douglass discovered the numerous so-called "lakes" or "oases" on Mars; and also established the presence of "canals" crossing the *dark* regions ("Maria") of the planet, thus proving that these dark areas were *not* "seas," as had previously been supposed. While in Peru, Professor Pickering discovered, by photography, the great whorls of diffuse galac-

tic nebulosity surrounding the entire constellation of Orion, having their center near the Great Nebula of Orion. Pickering and Douglass left Arequipa in 1893 to observe the total eclipse of the sun in that year from Chile; and the directorship of the Station was taken over by Professor Solon I. Bailey of Harvard. The Peruvian station was dismantled a few years ago, and the instruments moved to the new Harvard Station in South Africa, near Bloemfontein.

After returning to Boston in the winter of 1893, William H. Pickering met Percival Lowell, who, besides being a member of the well-known Massachusetts mill-owning family, was an ardent amateur astronomer. Professor Pickering interested Lowell in his own and Schiaparelli's work on Mars; and Lowell commissioned Pickering and Douglass to build an observatory for him in the western United States, to be devoted to the observation of that planet. Douglass went ahead with a 6-inch refractor, and tested a number of spots, Flagstaff, Arizona, finally being decided upon as the best one. In 1894 Pickering and Douglass built the first Lowell Observatory at Flagstaff, which was equipped with an 18-inch Brashear refractor and a 12-inch Alvan Clark telescope, mounted on the same polar axis. Pickering worked with Lowell and Douglass at Flagstaff for some months, during which time extended observations were made of Mars and Jupiter III. Finally, Professor Pickering returned to Harvard to work, for several years, on the analyses of his Arequipa observations, and other material. It was not until 1896 that Lowell obtained the present excellent 24-inch refractor from the Clarks. Professor Douglass remained at Lowell Observatory for several years, but eventually went to Tucson, Arizona, where he became Director of the Steward Observatory of the University of Arizona; and where he is today, doing excellent work on the relation of tree rings and solar cycles. Some years earlier, the two Sliphers and Lampland came to the Lowell Observatory from the University of Indiana at Bloomington, and have formed the basic element of its staff since Dr. Lowell's sudden death in 1916.

William H. Pickering continued work in Cambridge, at Harvard Observatory. In March, 1899, he made the photographic discovery of Saturn's ninth satellite, which he named Phoebe, and determined the rather startling fact that it revolved about Saturn in a direction *opposite* to the revolution of the other satellites and planets then known in the Solar System. The discovery plates of this satellite were taken by Professor Bailey, in 1898 from Peru, with the new 24-inch Bruce photographic doublet, at W. H. Pickering's suggestion, after previous attempts with the 13-inch Boyden refractor by Pickering had proven unfruitful, due to the faintness of the object, which turned out to be only of 15.5 stellar magnitude.

In the year 1899, equipped with an excellent 5-inch Alvan Clark refractor on a special mount, he undertook the first Harvard Observatory Expedition to the island of Jamaica in the West Indies. There he tested

the sky transparency and atmospheric steadiness, or "seeing," under high magnifications, on the planets and the stars. He found both factors very excellent in the Jamaican interior, away from the coast, and on a high plateau. He returned to Cambridge in 1900 to prepare the Second Jamaica Expedition, which returned to the island in 1900-1901. A 12-inch lens of 135-foot focus was mounted along a stationary polar axis on the side of a hill, (18° North Latitude), with a heliostat mirror at the southern end to throw the images of the moon and planets through the lens to a plate-holder at the focus in a specially constructed house. During a period of seven months, photographs of the moon, on a large scale, were made over the whole disk for each lunar phase. These, as published in Pickering's book "The Moon" in 1903, and in *Harvard Observatory Annals,* Vol. 51, were the best lunar photographs made up to that time, and their completeness is not duplicated, even today, by any other work. In all, 80 lunar plates of large size were published.

As early as 1899 W. H. Pickering first suggested the rocking-mirror method to determine the velocity of meteors. This type of apparatus was used, with notable success, by the Harvard Observatory meteor-study expedition to Northern Arizona, in the last few years, under Öpik and others. It was also about the same time that Professor Pickering first suggested, and developed in published form in several places, the explanation of the peculiar phenomena of reversal and change in the spectra of developing novae that is today accepted as correct; though it is often attributed to other astronomers. He realized that these changes must be due to a rapidly expanding envelope of "gas" surrounding the "new star," and correctly interpreted the observed spectral changes. The priority of William H. Pickering's explanation of novae spectra was not recognized until Dr. Dean B. McLaughlin's paper, recording it, was published in POPULAR ASTRONOMY in 1936. The present writer was in Jamaica with Professor Pickering at the time of the appearance of that paper, and had the pleasure of being the first one to show it to him, and of noting his enjoyment at the belated, but none-the-less welcome, recognition.

Professor Pickering returned to Cambridge in 1901, and again took up work under his brother at Harvard. In 1905 he reported the photographic discovery of a tenth satellite of Saturn, which he named Themis, though this discovery has not yet been fully confirmed. However, the presence of a tenth satellite of Saturn has very recently been upheld theoretically, on the basis of Bode's Law, by Mr. John Miller of the British Astronomical Association, in *Science* and in *Nature.* He feels that such a satellite *should* exist, and probably can be identified with the faint body reported by Pickering in 1905. For his work on the satellites of Saturn Pickering was awarded the Lalande Prize of the Paris Academy in this year, and the Janssen Medal in 1909. In 1905 he visited the island of Hawaii, and made some well-known studies of the volcanic crater formations there, in their similarity to those on the moon.

Other trips to Alaska and Canada, for the same purpose, were made about this time.

In 1907 he published his first major paper on the prediction of a trans-Neptunian planet, based primarily on the perturbations in the orbit of Uranus. This early work was prior even to Lowell's famous paper, which appeared in 1916. A little after this, Pickering visited the islands of the Azores, and made further studies of volcanic craters. After his return to Harvard in 1910, he was made an Associate of the Royal Astronomical Society of England. At the same time he undertook, and published, an extended statistical investigation of most of the known cometary orbits.

The year 1911 marks the founding of the Jamaica Branch of Harvard Observatory, at "Woodlawn," Mandeville, Jamaica, British West Indies, where Professor Pickering spent the majority of his later life. The primary instrument in use was the excellent 11-inch photo-visual Clark refractor loaned to Harvard by Mrs. Henry Draper. Constant visual observations of Mars, the moon, and Jupiter III, were begun, which were continued for the remainder of Professor Pickering's life. The first of his classical "Mars Reports," was written in 1913, and published in POPULAR ASTRONOMY. These Reports ran through 44 numbers, and were continued until 1930. They consisted of comprehensive analyses of a large number of observations and drawings of "The Planet," sent in to him, each opposition, by the International Associated Observers of Mars, of which he was Acting Secretary. The group of observers included, among other well-known planetary workers, the Reverend T. E. R. Phillips, Latimer J. Wilson, A. E. Douglass, G. H. Hamilton, Lowell, E. C. Slipher, and many others.

In 1921, after a trip to Europe, Pickering began the publication of a series of papers on unusual changes observed by himself and a few others in certain lunar craters, notably Eratosthenes. Though strongly criticized by many, he interpreted these changes as being due to minor depositions of frost, to lunar atmospheric haze in the bottoms of the craters, and to the growth of a fungus-like "vegetation" on the crater walls and floors as the sun attained differing heights over them during the long lunar day. The major changes that he observed have been corroborated by a number of observers, mostly advanced amateurs, and by photography, and there appears to be little doubt but that they *do* exist. The question of interpretation is one for the future, as Professor Pickering himself realized and often stated. His own "theory" was only a *working hypothesis;* and he did not seriously consider it much more than that.

At the age of 65 years, in 1924, he was retired by Harvard, at the usual age limit. The Observatory allowed him to retain the 11-inch Draper refractor until 1925, to complete observations of Mars at that opposition; and it was returned to Harvard in that year. The telescope is in use at the Cambridge Observatory at present, for objective prism

spectra in the Harvard Sky Survey. Pickering decided to retain the estate at "Woodlawn" as a Private Observatory, and first purchased a 10-inch reflector from an American telescope maker. This instrument was afterwards replaced by a 12.5-inch reflector by the famous English maker, Calver. In the early nineteen-twenties Professor George H. Hamilton, who had been observing Mars at the Lowell Observatory and elsewhere, came to Jamaica to work with Professor Pickering on Mars and Jupiter III. He later made 12-inch and 21-inch reflecting telescopes, and conducted his own private observatory at "Iona," a mile or so from "Woodlawn." Professor Hamilton died in the autumn of 1935, in Jamaica.

During the period from 1928-1932 Pickering published a number of papers, primarily in POPULAR ASTRONOMY, on one or more planets that he felt must exist beyond Neptune, in order to explain the unusual perturbations in the orbits of both Neptune and Uranus. Pickering's approach to the problem was primarily a graphical one, whereas the other investigators, notably Lowell, undertook more elegant mathematical analyses. However, when the planet Pluto was discovered photographically at the Lowell Observatory by Clyde Tombaugh in 1930, its actual position was slightly *closer* to Pickering's predicted position at that time than to that predicted by Lowell; though *both* solutions were farther off than in the case of Neptune's discovery. Most modern orbit computers, however, are of the opinion that *neither* Lowell's nor Pickering's solution to the problem was sufficiently well-founded to constitute a true proof or prediction of the planet's orbit. This opinion is especially strong since it has been found that Pluto, alone, has a mass which is not sufficient to cause the observed perturbations in the orbits of Neptune and Uranus. This fact caused Pickering, in 1931, to postulate the existence of several more disturbing bodies, with orbits beyond that of Neptune. In addition, the very early observations of "perturbations" of Uranus and Neptune from their "true" paths, upon which both Pickering's and Lowell's solutions are based, are not now considered sufficiently accurate to accept as justifiable data for the rigorous computation of the orbit of a trans-Neptunian planet. It is of interest, though, that Pickering and Lowell, by *different methods,* both reached solutions of quite comparable magnitudes and character, and both reasonably close to the position of Pluto when it was found. However, there can be no doubt but that the primary credit for the discovery of Pluto goes to the energetic staff of Lowell Observatory, for the long and successful photographic search that they conducted over a period of many years for a trans-Neptunian planet. Professor Pickering himself realized this, and so expressed it to the present writer.

It is of significance that as early as 1919, and at later times, W. H. Pickering sent predicted positions for the trans-Neptunian planet to Mount Wilson and to Harvard Observatories, as computed from his own theses. A number of plates were taken, and examined, at Mount

Wilson in the hope of finding the planet in the position predicted by Pickering, but were *apparently* not successful. However, after the recognition of Pluto on the Lowell Observatory plates by Tombaugh at Flagstaff in 1930, the Mount Wilson 1919 plates were re-examined, and, close to the position previously predicted by W. H. Pickering, Pluto was found. It was not identified on the earlier examination of the plates, because the search was not carried down to faint enough stars; the actual planet proving to be a good deal fainter than had been predicted by either Lowell or Pickering. Dr. Annie J. Cannon, writing in *Science*, for February 25, 1938, notes the amusing incident that when Professor W. H. Pickering learned that the name "Pluto" was to be given to the new planet, with the symbol "PL," he remarked: ". . . That's a good name, *P*ickering-*L*owell!" However, the proponents of Lowell's claims note, with equal validity, that the symbol "PL" also stands for "*P*ercival *L*owell." At any rate, Professor Pickering once told the present writer that he was one of the several persons who had suggested the name "Pluto" for the new planet, soon after its discovery.

In 1928 Professor Pickering made a trip to southern California and this proved to be his last to that region. In connection with this visit to California, it is interesting to note that the one thing he was most eager to do, next to hunting for Pluto on the Mount Wilson Observatory plates, was to revisit the Yosemite Park. He had been there once before, fifty years previously in 1878, as a young man of twenty; and on that occasion had climbed the Half Dome. He was one of the first men to do this, and one of the very few who climbed the Half Dome at all before the iron spikes and chain guards were installed. He was perfectly delighted with the Yosemite when he visited it again in 1928, and would stand for long periods admiring the falls and the towering rock masses. In later years he often said that he wanted to see Yosemite again before he died, but he never did. He was a great climber in his younger days, and was always a lover of the mountains and the great outdoors. He visited Mount Wilson Observatory, saw the vast changes since the early days when he had founded the first Harvard Station there, and spent several nights observing fine crater detail on the moon with the 100-inch reflector. He was very pleased with the fine definition of this instrument, and looked forward to the time when the building of larger telescopes, notably the new 200-inch, will release the 100-inch for more lunar and planetary photography. It is well known that Professor Pickering's eyesight was excellent in earlier days, and he, like Schiaparelli, always strove to keep it so by avoiding excessive stimulants such as tobacco. Undoubtedly, much of his success as a visual planetary observer, like that of Lowell and Schiaparelli, rests upon his ability to detect faint detail and small contrasts. In his prime, under good atmospheric conditions, Pickering could locate *thirteen* stars in the Pleiades cluster with the naked eye, whereas, if most of us can see more than six to nine, we consider our sight unusual. Lowell said

that he could detect *sixteen* Pleiades, but his sight was undoubtedly extraordinarily good, as is evidenced by the *very* delicate detail recorded on his drawings of the planets.

While on a European trip in 1930-31, Pickering visited England, France, Germany, and Italy, having many stimulating discussions with astronomers in those countries, principally about Pluto and Martian problems. He was long a close friend of Dr. A. C. D. Crommelin, the British expert on comets; of Professor Max Wolf of Heidelberg, whose work on the minor planets is well known; and of the great French astronomer Camille Flammarion, before the latter's death. Pickering also knew personally the Italian planetary observer Maggini, and the independent French planetary astronomer, comparable with Lowell, Jarry-Desloges, who, with the keen-sighted Fournier brothers, founded several planetary observatories in France and Northern Africa (Algiers).

In the summer of 1932, after helping with observations of the total solar eclipse of August 31, from New England, Professor Pickering attended the great meeting of the International Astronomical Union at Cambridge that followed the eclipse. He then returned to Jamaica for several years of work, primarily on meteors and lunar observations.

In the summer of 1935, after he had returned to Jamaica once more, Professor Pickering had with him, at "Woodlawn," a young student of astronomy. Mr. Walter H. Haas, now of the Mount Union College Observatory, Alliance, Ohio, and Director of the Lunar Observation Section of the American Amateur Astronomical Association, studied and observed, primarily the delicate lunar detail and abnormal crater changes, under Professor Pickering for several months. He corroborated many of the unusual changes previously reported by Pickering, and since 1935 has extended this type of work further to include observations of lunar crater color changes. He has published reports in POPULAR ASTRONOMY and elsewhere.

In 1936 the present writer also went to Jamaica and worked for a memorable period from April to July, under Professor Pickering, observing the planets and the moon. This experience was described in POPULAR ASTRONOMY in 1937. At this time Professor Pickering was working on a new composite map of Mars which he had been planning for some years. It is composed from drawings sent in to him by the Associated Observers since 1913, and published in POPULAR ASTRONOMY in the "Mars Reports." It is designed for the use of the actual *observer,* being divided up into twelve sections, each section covering 60° of longitude on the planet, with one set of six maps for each hemisphere. There is overlapping in the Equatorial Regions and for 15° of longitude on each limb as well. It is hoped that it will be possible to edit and publish posthumously, within the next year or two, the completed Pickering Map of Mars, as he had completed the major portion of it before his death.

At this point we might also note that Professor Pickering was re-

sponsible for many of the basic ideas in the hypotheses of Lowell, and others, which attempted to explain the so-called "canals" of Mars. It was Pickering who first suggested to Lowell the theory that the observed dark bands on the planet are due to a species of "vegetation," *bordering* water-channels on both sides for forty miles or so of diameter. Though Pickering did not himself retain this hypothesis for long, he felt about it, as did Schiaparelli, that it was the best "working hypothesis." It has also often been stated and written that the original English translation of Schiaparelli's papers on the discovery of the Martian "canali" erred in translating the word *"canali"* as *"canals,"* and thus gave rise to a definite misimpression to English readers of what Schiaparelli claimed to have observed. It so happens that Professor Pickering was the one who made these disputed original translations of the Italian observer's papers, and he claimed that *"canals"* was just what Schiaparelli *did* mean, though Pickering was not always in accord with this view himself. Needless to say, the question of the nature and origin of the bands on the planet, whether they be sharp and narrow, or broad and diffuse, and whether vegetation bordering actual artificial water-channels, or merely rain-shower tracks on the Martian desert surfaces as Pickering later thought, is still far from being solved. The actual existence of some sort of elongated bands and lines on the surface of Mars, in the *positions* drawn by Lowell, Pickering, and others, cannot be denied, as their presence has too often been corroborated by many excellent observers and by many good photographs. At least the major "canali" *do* exist, as we have evidenced them. However, years of visual observations have not yielded much more than this fact alone; and it is now evident that we must turn to some form of reliable astrophysical observation and analyses if we are to learn more of the true nature and characteristics of the Martian surface. Pickering himself early recognized that no *real* gain in astronomical knowledge would be brought about by merely drawing and re-drawing dozens of very faint and difficult, if not doubtful, "canali," every time they appeared to the observer. He therefore urged that more accurate and complete observations be made of the *major* and undoubted "canali," and of the seasonal changes and other definite features of the planet; and that they be subjected to accurate and thorough analyses. He, himself, founded a basis for such observations with photography, polariscopes, and accurate color analyses. It is for the future to justify this attitude; and, indeed, the advances made in our knowledge of the planet, by such observations in the form of advanced photographic and radiometric techniques by Wright, Slipher, Ross, and Lampland, among several, in recent years, seem to point the way toward such a justification.

Though there can be no doubt but that the study of the planet Mars was the greatest interest of W. H. Pickering's life, his lunar work, previously mentioned, and the study of the changing disk forms of Jupiter III, in addition to the trans-Neptunian planet, occupied most of his later

years. In the early years, he also made observations of Mercury, with Douglass in Peru, and of Venus from Jamaica. An analysis of his observations of the latter, by Mr. Henry McEwen, Director of the Mercury and Venus Section of the British Astronomical Association, yielded a hypothetical rotation period of about 68 hours for Venus. Pickering's observations of Jupiter's Third Satellite indicated a rotation period for it of *less than one earth day;* though considerations by other astronomers do not agree, many feeling that its period of rotation equals that of revolution about Jupiter: 7 days; and a few supporting a period of the order of magnitude indicated by Pickering.

In the year 1937, after I had returned to the United States from Jamaica, I received a number of letters from Professor Pickering at different times, indicating his fully sustained interest and enthusiasm for the problems of planetary astronomy. Though he was feeling quite ill a good deal of the time, he still sent his 12.5-inch Calver speculum to Boston with Mrs. Pickering, when she made a visit to the States in that year, and had it aluminized preparatory to further observational work from Jamaica. He wrote that he contemplated coming to the United States again rather soon, but did not live to fulfill this desire. In the spring of 1937 he very kindly suggested that I again come to Jamaica to do further observational work on the planets with him. However, as I was working at the Mount Wilson and Griffith Observatories in Southern California during that spring and summer, I could not arrange the trip, much to my eternal regret, for I had hoped to see and talk with Professor Pickering once more.

William H. Pickering's principal contributions to *The Annals of Harvard Observatory* will be found in volumes: **32**, **33**, **51**, **53**, **61**, and **82**. In addition to his 44 "Mars Reports" in POPULAR ASTRONOMY, from 1914-1930, he published many papers there on a variety of astronomical subjects too numerous to list. Early papers appeared in *The Sidereal Messenger,* and *Astronomy and Astrophysics,* forerunners of POPULAR ASTRONOMY, and *The Astrophysical Journal.* Pickering published numerous later papers as well in *The Publications of the Astronomical Society of the Pacific, The Journal of the British Astronomical Association,* and *The Journal of the Royal Astronomical Society of Canada.* While in Jamaica, I brought up to date a catalogue of his published papers and work, which ran to well over *450* entries! Observations by Pickering on Mars and Jupiter III also appear in *The Annals of Lowell Observatory,* Volumes I and II. He published at least two books: "The Moon" in 1903, and "Mars" in 1921. Pickering could not uphold the Einstein Theory of Relativity, as he interpreted it, and he published several papers on it and the theory of Gravitation, approaching the subjects from the physical, rather than the mathematical point of view. In his large library at "Woodlawn," which he felt was probably the best astronomical library in the West Indies, are several hundred thick notebooks, filled with his closely-written observations and drawings of the moon

and the planets, and with the data of visual acuity tests and photographic records. The fascination and wealth of these voluminous notebooks are as enticing as was the rich personality of the man himself.

Perhaps it might be of interest to note that though William H. Pickering was not primarily a solar observer, he observed, and either conducted or aided in expeditions which have recorded at least six total solar eclipses; notably: Colorado in 1878, Grenada, West Indies, in 1886, California in 1889, Chile, South America, in 1893, Georgia in 1900, and New England in 1932. Surely an enviable record for any solar astronomer, let alone one whose major efforts were concentrated on the planets!

William H. Pickering early married Miss Anne Atwood, daughter of Mr.Isaac Butts of Boston. Mrs. Pickering accompanied Professor Pickering on many of his foreign travels and expeditions; and they visited England together a number of times, making many friends there. Professor Pickering is survived by Mrs. Pickering, who is still living in Jamaica, at "Woodlawn," and by their two children: a son, Mr. William T. Pickering, who lives with his family in Pasadena and San Marino, Southern California, and a daughter, Esther, who is Mrs. Merton S. Harland of Alberta, Canada.

In addition to the Lalande Prize in 1905, and the Janssen Medal in 1909, previously mentioned, Professor Pickering was awarded two medals from the Societie Astronomique de Mexico; and the Order, *Chevalier,* of St. James of Portugal was bestowed upon him. He was a member of the American Astronomical Society, the American Academy of Sciences, the Société Astronomique de France, and was an Associate of the Royal Astronomical Society of England, an honorary member of the British Astronomical Association, the Royal Astronomical Society of Canada, and a member of the Harvard Travellers' Club, and the New York Authors' Club. He retained an active interest in outdoor life, and in the sport of mountain-climbing, and regularly subscribed to several periodicals in this and similar fields of enthusiasm. He was a member of the International Astronomical Union Committee on Physical Observations of the Planets and Satellites, and, in 1935, the Lunar Section of this Committee of the I.A.U. named an unusual crater "W. H. Pickering" in his honor. He had made a long study of the abnormal changes exhibited by this object, which was previously known as "A," and its nearby twin companion as, "Messier." There was already another lunar crater named in honor of his brother, "E. C. Pickering."

It has not been the present writer's intention to attempt to give here a description of the personal characteristics of Professor W. H. Pickering, aside from those obvious traits that can be inferred from such a long and exceedingly prolific life. I will leave for another, who is better fitted than I, the task of relating anecdotes and pleasant sidelights on the life of this unusual and inspiring man.

However, I cannot refrain from recalling one of many cherished

afternoons in 1936, when we were sitting with our tea on the veranda at "Woodlawn," watching the exquisite tropical twilight and dusk fall gently, but swiftly, over the valley below. Deeply moved, I recited aloud that haunting, yet invincibly brave, anonymous couplet that marks the resting place of John and Phoebe Brashear in the base of Allegheny Observatory in Pittsburgh. . . . The Professor chuckled softly; and said that, ". . . yes, he liked it too; and *he* knew who had written it." Though I never did learn from him who was the author of these words, there can be no more fitting final comment on the life of any astronomer who has given so many years devotedly to his work, as did William Henry Pickering:

"We have loved the stars too fondly,
To be fearful of the Night."

726 N. Elmwood Avenue, Oak Park, Illinois.

On the Fall of the Great Siberian Meteorite, June 30, 1908

By I. S. ASTAPOWITSCH

[*Much has already been written about the very exceptional meteorite of June 30, 1908, several articles, indeed, having appeared in this magazine. Nevertheless it is thought fitting that this authentic account, prepared by one who has visited the region of the occurrnece, be published both because of its intrinsic interest and for the sake of record.*—Editor.]

The remarkable phenomenon of he fall of the great Siberian meteorite,[66] which happened on June 30, 1908, occurred in a scantily populated region (about 1 person per sq. km.) of a swampy taiga (Lat., 60° 57′, Long., 101° 57′ E, 1929), where only a few nomad-Tungus were the direct witnesses of this exceptional event. The mechanical effects were felt by Tungus I. Potapovich, A. Machakugyr and his family, V. Okchen, Tungus Podyga's sons: Chekaren, Chuchancha, and Nalega with their families, and possibly others. The heat radiation was felt by peasants S. Semenov and P. Kusolapov at Vanovara, 65 km. distant.[19-21] The light phenomena were observed by about a hundred witnesses at Kejma, 180 km. distant, Chadobets, Teterya, and many other villages on the Angara, also on the Lena gold fields and South-Enisseisk forest.[15-17] The flight of the meteorite (about 7^h A.M.) was also observed by many people up to 450 and 500 km. distant. The general length of the real path in the atmosphere was over 500 km. from SSW to NNE and the meteorite's flight ended in a powerful explosion which took the form of

a vertical column of fire not less than 20 km. in height which was observed from Kirensk (450 km.), Nijne-Ilimsk (400 km.), Nijne-Korelinsk (450 km.) and with remarkable effects at Vanovara (65 km.). The flash of the explosion was comparable to the sunlight in brightness and was observed, as above mentioned, from the distance of about 600 km. (South-Enisseisk taiga) and 850 km. (Lena gold fields). It is a well-known fact,[50] that this explosion called forth seismic waves which were recorded by the Repsold and Milne's seismographs at Irkutsk Geophysical Observatory (970 km.) and also at Tashkent Observatory (3050 km.), Tiflis (4390 km., Milne seismograph), and Jena, Germany (5230 km., Wiechert's pendulum). The explosion also generated a group of air waves,[66] sound phenomena of a low frequency, which were heard (about 100 reports) in a region of the form of an almost perfect circle having a diameter of 12°.5 of the meridian arc (1350-1400 km.). Its center lies near Vanovara (Lat., 102° 17′, Long., 60° 20′ E., 1929). The sound waves were propagated for 30-35 minutes, whilst the infrasonic ones travelled around the earth (records of Batavia, Washington,[69] and Potsdam[52] barographs) and died down after 30 hours (after 1908 July 1, $7^h\,20^m$, Fuess' barograph, Potsdam).

There is also mention of the action of ballistic waves. The detonations of Mach's ballistic waves were recorded by several observers and F. W. J. Whipple,[50] of Kew Observatory, found them on the records made by the English microbarographs at $5^h\,25^m$ G.M.T. (South Kensington, Leighton Park, Westminster, Reading Sc., Cambridge, and Petersfield).

Tungus who usually make their summer camps in the hills, and those who were located near the site of the fall, suffered considerably from the air shock. L. A. Kulik,[19-21] of the Leningrad Academy of Sciences, has discovered the radial action of the explosion in the direction of the wind-fallen trees; the limits of wholesale scorching as well as of whole and partial falling down of trees are concentric circles; the radius of the circle of uninterrupted wind-fallen trees is 50 or 60 km., but the author of this article has no information concerning the western and northern sides.

The reason that many years passed after the fall of the meteorite and before the first scientific researches were started lies in the fact of the scantily populated region of a swampy taiga. D. O. Sviatsky, editor of the journal "Mirovedeniye," Leningrad, found by accident in 1921 an indication[7] concerning the fall of a great meteorite in Central Siberia. L. A. Kulik[10-14] collected many observational data during his Siberian expedition of 1921-1922. The geologist S. V. Obruchev in 1924 obtained the first map of the region of the meteorite's fall and then in 1925 Professor A. V. Voznessensky, former director of the Irkutsk Geophysical Observatory, published his data[15] of great interest. Another scientist, ethnographist, I. M. Suslov, in 1926 independently collected many interesting data;[17] these data helped to establish exactly the region of the fall, where the taiga was scorched; this was a place, situated to the

NNW of the Vanovara trading point, situated on the Podkamennaya Tunguska River (Khatanga). A special meteorite expedition was organized in 1927 by the Academy of Sciences, Leningrad, under L. A. Kulik's leadership.[23] Numerous data were collected in connection therewith. L. A. Kulik[24, 31] in a second expedition in 1928 discovered the place of the meteorite (meteorites!) fall. The determination of the three astronomical points was effected by S. Y. Belykh,* a topographical and magnetometrical survey (L. A. Kulik) and also a cinematographic documentation (N. Strukov[25]). During the new expedition of 1929-1930, L. A. Kulik[62, 63] investigated the details of the fall. Near the place of

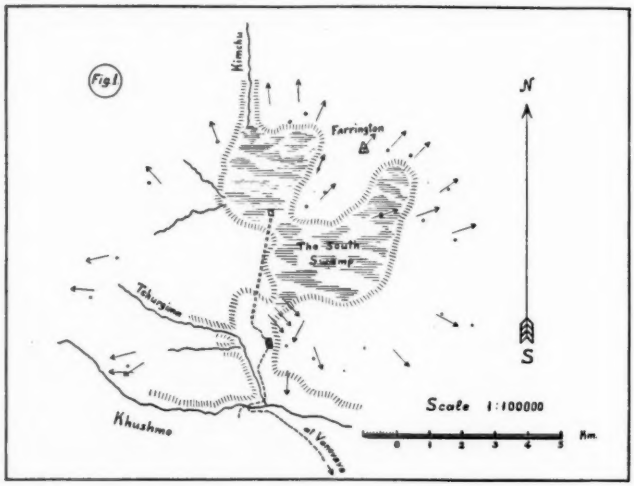

FIGURE 1

THE PLACE OF THE FALL OF THE GREAT METEORITE OF 1908 JUNE 30, ACCORDING TO L. A. KULIK.

The arrows show the direction of the wind-fallen trees (L. Kulik). Δ—the astronomical point "Farrington" (Lat. 60° 54′ 59″0, Long. 101° 56′ 59″7 E).

the fall the coniferous taiga was uprooted and burnt for a radius of 10 to 15 km. by the action of the very hot explosive waves; on high places the trees were uprooted for a distance of 50 to 60 km; about 8000 sq. km. of forest was blown down. Near the center of the area of uprooted trees the top layers of peat were piled up in folds by the pressure of the air and many pieces were turned right over; a larch-tree cone with unripe grains was found at a depth of 1 meter. A bore-hole to a depth of

*They are: (1) Farrington, a mount 3 km. NNE of the center of the wind-fallen trees (Lat., 60° 54′ 59″0, Long., 101° 56′ 59″7 E); (2) Shakrama, a mount 18 km. S of the Farrington (Lat., 60° 44′ 18″2, Long., 101° 55′ 17″8 E), and (3) Vanovara factory (Lat., 60° 20′ 18″2, Long., 102° 17′ 06″0 E).

31.5 m. showed peat mixed with mud, clay, and aquiferous sand. A strange acute-angled material was formed as a result of the explosion, breaking up the surrounding strata into small pieces. V. Yankovsky, a meteorologist, says that there was a quantity of vitreous, porous mass in dark blocks of some hundred grams (1929). According to L. A. Spencer (British Museum, London) "glassy" meteorites (tectites) are of the same origin. In general this region consisting of Siberian diabase (trapps) is covered with diluvial deposits. This region is very hilly and in places marshy (see Figure 1). The trees were burned to 20 per cent of their radii up to 20-30 km. from the center of the wind-fallen trees; all the trees have neither branches nor twigs. The trees were broken at about ¾-⅔ of their height.

The author began to collect new data in 1928.[40, 31, 43] In 1930-1932 he made astronomical and geophysical researches on the rivers Angara and Lena and collected on the spot a number of statements and material, which he later supplemented in Irkutsk, Slutsk, Moscow, and Leningrad. During a geophysical expedition to the Podkamennaya Tunguska the geophysicist, A. Ovchinnikov, (Irkutsk Geophysical Institute) made a route survey in the region of the fall (August, 1932) and handed the data over to the author, who plotted a map of the region of the fall (near the rivers Chambe and Khushmo and Shakrama Mount). A. V. Voznessersky[15] states that in 1908 at Kirensk (Lat., 57° 47′, Long., 108° 07′ E) a barograph with a weekly chart recorded an air wave; according to the writer's measurements of the original barogram, the amplitude was 1.10 mm., (the distance from the explosion was about 450 km.). This led the writer to investigate the automatic records of 30 June 1908, at the meteorological stations within the territory of the present Eastern Siberia, Buriato-Mongolia, Yakutia, and part of Western Siberia. Thanks to the kind coöperation of A. Ovchinnikov, A. Treskov (Irkutsk), and other persons, in 1930-1933 the barograms in Siberia and the microbarograms at Moscow, Slutsk, and Leningrad were examined by the author. Barographs (Naudet and Richard) of 18 stations in Siberia recorded the passage of this air wave; the measurement of the barograms established the moment of the air wave passage at each station. Therefore the moment T_0 of detonation of the meteorite is established, taking the value of the rate of propagation of the air wave to be 19.09 km/min, as $T_0 = 0^h\,18^m.6 \pm 2^m.2$ G.M.T. (13 stations). The greatest amplitudes were 2.45 mm. (Tulun, Lat., 53° 33′, Long., 100° 22′ E, 660 km.); 1.65 mm. (Irkutsk, 970 km.); 1.60 mm. (Sretensk, 1230 km.), etc. Records of the stations Khatanga (Lat., 71° 59′, Long., 102° 20′ E, 1110 km.), Perevalnaya (Lat., 51° 44′, Long., 112° 37′ E, 1160 km.) and Verkhayansk (1680 km.) were obtained also. On the seismogram secured in Irkutsk may be seen the triple damping oscillations (period of 2.3 min.) superimposed upon seismic oscillation and produced by the same air wave; the seismogram gives $T_0 = 0^h\,16^m.0 \pm 0.7$ min. G.M.T. The microbarograms in Slutsk Geophysical Observatory near Leningrad

(Sprung's microbarograph) give $T_0 = 0^h\ 15^m.0$ G.M.T., with the oscillation period about 2.4 min. and the amplitude A = 0.22 mm. Reinacher barogram at Leningrad gives $T_0 = 0^h\ 17^m.6$, A = 0.2 mm. On the weekly Richard barogram at the Moscow Geophysical Institute, the writer discovered no noteworthy deviations (1 mm. = 0.5 mm. Hg). On the other Sprung dotted barogram at Slutsk the dot made at $5^h\ 40^m$ P.M. shows a deviation 0.2-0.3 mm.[65, 66, 70]

It is well known that an excellent study of English barograms was made by F. J. W. Whipple.[50] The records were noted by W. N. Show as early as 1908, but it was only in 1929 that C. J. P. Cave connected the Petersfield gram with the fall of the meteorite. For the English microbarograms W. F. J. Whipple gives A = 0.16 mm., period of the oscillations 2.2 min., in good agreement with the Soviet records.

Other records were found in Batavia and Washington. R. Süring gives[52] for Sprung-Suess barographs of Potsdam, Schneeköppe, and Berlin the amplitudes, respectively, 0.57, 0.25, and 0.25 mm., and A = 0.43 mm. for the ballistic wave (Potsdam); the second wave (from the antipodes) is of 0.13 mm. (Potsdam). The mean velocity of the wave propagation is 320 meters/sec. It is very probable that new records of the Japan, Indian, etc., barographs will be found; the waves should have been recorded by all microbarographs of the world.

The sound phenomena also enable us to determine the moment of explosion which has already been accomplished by A. Voznessensk, for five stations and supplemented by the author.[66] From the seismogram at Irkutsk (Repsold and Milne's horizontal pendulums) $T_0 = 0^h\ 15^m.1$; the seismic waves of the Rayleigh type, which do not penetrate deeper than the granite stratum, had a velocity of propagation of 3.1-3.2 km/sec. (A. Treskov, Irkutsk). A summary of the results is given in Table I.

TABLE I

DETERMINATION OF THE TIME OF FALL OF THE METEORITE OF 30 JUNE 1908.

No.	Source of Determination	Time G.M.T. h	m	m
1.	Barograms of 15 stations in Siberia	0	12.6	± 2.2
2.	Sound phenomena at 5 points		16.0	± 2.9
3.	Sound phenomena at 5 points		15.4	± 3.6
4.	Seismogram (Irkutsk), air waves		16.2	± 0.7
5.	Seismogram (Irkutsk), seismic waves		15.1	
6.	Sprung's microbarogram, Slutsk		15.0	
7.	Reinacher's barogram, Leningrad		17.6	
	Mean	0^h	$16^m16 \pm 31^s$	

The degree of intensity of the explosion (or in other words of energy generated by the explosion) may be determined from various considerations.[65, 66] Acoustic phenomena, assuming that sounds of very low frequency were heard 700 km. away from the site of the fall, gives the lower limit of the intensity of explosion to be 10^{17} erg/sec. Comparison with the eruption of the Cracatoa volcano gives the energy de-

veloped by the meteorite in its fall 10^{21} ergs. Comparison with the force of strong hurricanes may give the intensity of explosion at the fall 10^{20} erg/sec. Comparing the description of several earthquakes of known effect (*e.g.* at Sakurashima, Japan, 1917 January 12; Ischia, Tyrrhenian Sea, 1881 March 7, etc., A. Sieberg, *Geologische Einführung in die Geophysik*, Jena, 1927) with that caused by the fall of the meteorite according to witnesses and seismographs, it may be concluded that the upper limit of energy generated by the meteorite is roughly $\leq 10^{21}$ ergs. The light phenomena, observed at the moment of the explosion in full daylight, give the intensity of the explosion within the range of 2×10^{19}-10^{24} erg/sec. The area of overthrown forests extends to about 8000 sq. km.; taking the mean forest technical indices of this region and applying the theory of resistance of materials for pine and larch, it is possible to compute, knowing that about 8×10^7 trees have been thrown down or uprooted in the above area, the power required for such an act, which is equal to 4.4×10^{21} ergs. F. J. W. Whipple gave[50] an example of computing the energy of air waves in the reduction of the English microbarograms; a similar computation has been made by the author for the barogram obtained in Slutsk which gives the effect of the explosion 0.5×10^{20} ergs. As to the final result, we may assume the figure 10^{20}-10^{21} ergs. In the absence of accurate measurements these estimates of the force of the explosion are very rough and give only the order of the value to be determined when taken in connection with each other.

TABLE II

ENERGY OF THE EXPLOSION CAUSED BY THE FALL OF THE METEORITE.

No.	Method	Power erg/sec	Work erg
1.	Limit of audibility of sounds	$>>10^{17}$	
2.	Comparison with Cracatoa eruption		$\leq 10^{21}$
3.	Comparison with force of hurricanes	$>5\times10^{20}$	
4.	Comparison with earthquakes		$\leq 10^{21}$
5.	Absolute luminosity of explosion	$>2\times10^{19}$,	$<10^{24}$
6.	Wind-fallen trees		$> 4.4\times10^{21}$
7.	Energy of air waves (Slutsk)		$> 0.5\times10^{20}$
8.	Energy of air waves (England, by Whipple)		$> 3.2\times10^{20}$

Physical condition of the flight of the meteorite could be established on the basis of statements made by many witnesses. The visible brightness of the meteorite at a distance of 200-300 km. was certainly greater than that of the full moon (-14^M), but less than that of the sun (-26^M); very few fireballs were as bright as that. The absolute brightness of the fireball was of the order 10^{10} to 10^{15} international candles. The color of the meteorite gaseous envelope was white with a light blue shade and shows that its temperature was very high; this leads us to suspect a great geocentric velocity over 40 km/sec. The form of the head of the meteorite was round, its visible diameter was half that of the moon or actually 0.5 to 2.0 km. (ordinary fireballs have diameters of a few hundred meters). The meteorite left behind it a vanishing train of thermally ionized air.

The mass of the meteorite, assuming its considerable geocentric velocity, may be estimated within the limits of 2 to 200 tons.

The trajectory of the flight, directed from SSW to NNE, had a slope towards the horizon of not more than 18° to 24° ; the azimuth of the trajectory is confined between S 16° E and S 26° W, and the inclination to the horizon $4° < i < 24°$; the possibility ($i < 4°$) of the flight of the meteorite right through the atmosphere, quite possible with trajectories having such slopes in general (*e.g.* the fireball of 1868 September 5, etc.) is quite excluded in this case. The radiant of the meteorite lay in the constellation Cetus, to the south of the ecliptic, not far from the earth's apex; no other noticeable radiants have been observed here at that epoch. It is worthy of mention that a stony meteorite (chondrite) fell at Kaharlyk, near Kiev, Ukraine (end of June, 1908).

The Siberian meteorite of 1908 June 30 struck the earth in the ascending node of its orbit, which was probably a hyperbolic one; its movement in the orbit was reversed. The meteorite had passed the perihelion of its orbit, which was inclined slightly to the ecliptic.

The flight and fall of the meteorite must occupy one of the foremost places because of the magnitude of the phenomena accompanying its motion. Similar phenomena were described only in the meteorite fall of 1290 June 25 near Veliki Vstiug, Russia (D. O. Sviatsky, Astronomical Phenomena in the Russian Chronicles, Petrograd, 1915, pp. 178-180; Mirovedeniye 17, 1928, p. 119), in 1800 April 5 in North America (Howard, *Ann. d. Physik*, 13, 1803, p. 457), and possibly in 1856 August 31, near Kirensk, river Lena, Eastern Siberia (W. Obrutchev, Priroda, 22, 1933, pp. 113-114, Leningrad). It is unlikely that we may again (during the 20th century) be witnesses of a similar meteoric phenomenon.

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Leningrad State University, September 25, 1934.

The Central-Epoch Method in Proper-Motion Work

By KNUT LUNDMARK

Having read recently the very interesting paper: "The History of Astronomy in Williams College and the Founding of the Hopkins Observatory," by Dr. Willis I. Milham, and the interesting biography of the versatile American astronomer, Truman Henry Safford, included in that paper, it occurred to me that it might be of interest to point out that Professor Safford seems to have been the first one to introduce the method for the derivation of stellar proper motion, sometimes referred to as the "central-epoch method."

The determination of proper motion in its classical form is a simple application of the method of least squares. Let the different stellar positions, reduced to a certain equinox, weighted, and corrected for systematic errors, be α_1 and δ_1, and denote the weights (which need not be equal in both coördinates) p_1, then the equations of condition, for determining the proper motion in right ascension, can be written.

$$p_1 [a + \mu (t_1 - t_1)] = p_1\alpha_1,$$

and, similarly,

$$p_1 [a + \mu (t_1 - t_1)] = p_1\delta_1,$$

for declination, where a is a constant, μ the proper-motion component in question, and t_1 a certain zero-epoch.

Introducing a central-epoch t_0, defined as

$$t_0 = \Sigma p_1 t_1 / \Sigma p_1,$$

or the weighted mean of the epochs of the different observations, and forming, analogously,

$$\alpha_0 = \Sigma p_1 \alpha_1 / \Sigma p_1, \text{ and } \delta_0 = \Sigma p_1 \delta_1 / \Sigma p_1,$$

and the following differences

$$\Delta\alpha_1 = \alpha_1 - \alpha_0 ; \ \Delta\delta_1 = \delta_1 - \delta_0, \text{ and } \Delta t_1 = t_1 - t_0,$$

we have finally:

$$\mu_\alpha = \frac{\Sigma p_1 \Delta t_1 \Delta\alpha_1}{\Sigma p_1 \Delta t_1 \Delta t_1}$$

$$\mu_\delta = \frac{\Sigma p_1 \Delta t_1 \Delta\delta_1}{\Sigma p_1 \Delta t_1 \Delta t_1}$$

In spite of the fact that the part of the derivation of proper motion involving the least squares solution is, indeed, small in comparison with the foregoing work (reduction to equinox, applying or deriving systematic corrections, and assigning or deriving weights), still it is quite clear that the simplification of the solution sketched above is very important in practice as saving much labor. Besides, it is easy to form a number

of independent and reliable checks.[1]

The first time, known to me, when this central-epoch method was established, is in T. H. Safford's work, "Catalogue of the Mean Declination of 2018 Stars, etc., Washington, 1879." In the Introduction to the work mentioned, which has many interesting points, details as to the reduction of a set of observations by use of a central epoch are given on page 12. I do think that it tells us something about Safford's vast intellectual abilities in that he was of a type that could make the reading of the introduction to a star catalogue very interesting.

The feeling that it generally, at least in Europe, has been forgotten who introduced this method has caused me to write the present lines. It is not only in textbooks, general accounts, and special investigations relating to the derivation of proper motion that I have noticed that Safford's work in the said respect seems to be unknown or forgotten. Having directed quite extensive determinations of proper motion at Lund, I have observed that the astrometrists of today generally are not acquainted with the importance of T. H. Safford as an astrometrist.

Of course, the tradition in America with regard to her outstanding astronomers is living in quite another way than in Europe where the personal relations with the older and younger generation of American astronomers are good but not widespread enough. For my personal part I have enjoyed listening to many interesting personal memoirs and recollections of the highly gifted astronomer, mathematician, lightning calculator, teacher, and the remarkable character, Henry Truman Safford. Especially so have Drs. R. H. Tucker and R. G. Aitken told me much about him.[2]

The purpose of the present lines is to call attention to the establishment by T. H. Safford of a method of calculation in the branch of astrometrics which has proved to be of much importance on account of its convenience and labor-saving.

Lick Observatory, Mount Hamilton, California, April, 1938.

[1] For that the reader can consult H. S. Davis, "Declinations and Proper Motions of Fifty-Six Stars," Observatory of Columbia College Contribution, No. 8, New York, 1895, which gives a comprehensive and detailed account of the method and also mentions the priority of Safford. This paper has served in many instances and can still serve as a model for the arrangement of proper motion derivation in a systematic way.

[2] In the well-known and interesting book, "The Reminiscences of an Astronomer, Boston and New York, 1903," Simon Newcomb tells about Safford as "the most wonderful genius in the [Nautical Almanac] office" and also states "that the power of continuous work was no greater in him than in others, nor did he succeed in doing more than others in the course of a year."—This statement, which, of course, does not diminish the admiration one feels for the genius of T. H. Safford might contribute to explain why the unusually highly gifted man did not reach up to the rank of a leading astronomer of his generation. It might also be inferred from what has been written and told about Professor Safford that he was perhaps more of a receptive mind than of a constructive one! But the main point is probably touched in Newcomb's statement that he had not more than average power for continuous work.

Planet Notes for July and August, 1938

By R. S. ZUG

Note: Greenwich Civil Time is employed, unless otherwise stated. To obtain Eastern Standard Time subtract 5 hours; Central Standard Time, 6 hours; etc. The planetary phenomena are described as they are to be seen from latitude 45° N. The data are taken chiefly from the *American Ephemeris and Nautical Almanac.*

Sun. The positions of the sun for July 1 and July 31, respectively, are: $\alpha = 6^h\ 37^m.0$, $\delta = +23°\ 10'.4$; $\alpha = 8^h\ 38^m.1$, $\delta = +18°\ 29'.6$. The corresponding positions for August 1 and August 31, respectively, are: $\alpha = 8^h\ 42^m.0$, $\delta = +18°\ 15'.0$; $\alpha = 10^h\ 34^m.6$, $\delta = +8°\ 58'.1$. The sun's course is again turning southward toward the autumnal equinox. Beginning the month of July in the constellation Gemini, the sun enters the constellation Cancer on July 20. On August 10 the sun leaves the constellation Cancer and enters Leo. The earth reaches aphelion, its greatest distance from the sun, July 3, 4^h. On this day the earth is 3,109,000 miles farther from the sun than at the time of perihelion passage in January.

Values for the equation of time are as follows:

Date 1938	Equation of Time (Mean - Apparent) m s	Date 1938	Equation of Time (Mean - Apparent) m s
July 3	+ 3 52	Aug. 4	+ 6 4
7	+ 4 34	8	+ 5 39
11	+ 5 11	12	+ 5 6
15	+ 5 41	16	+ 4 23
19	+ 6 3	20	+ 3 32
23	+ 6 17	24	+ 2 33
27	+ 6 22	28	+ 1 28
31	+ 6 18	Sept. 1	+ 0 16

Moon. Phenomena of the moon will occur as follows:

		h	m
First Quarter	July 4	13	47
Full Moon	12	15	4
Last Quarter	20	12	19
New Moon	27	3	54
First Quarter	August 3	2	0
Full Moon	11	5	57
Last Quarter	18	20	30
New Moon	25	11	17
Apogee	July 11	21	
Perigee	26	11	
Apogee	August 8	3	
Perigee	23	17	

Mercury. Mercury is an evening star July 1, although inconspicuous. The planet attains its greatest eastern elongation July 31, 17^h, at which time it will be 27° 15′ from the sun. The stellar magnitude at that time will be +0.6. The elongation is comparatively great, due to the nearness of the planet to its aphelion point. (Aphelion is reached August 6.) However, the elongation is a poor one from the observational point of view, as the altitude of the planet at sunset is only 10°, and it will therefore set soon after the sun. Inferior conjunction will occur August 28, 9^h.

Venus. The planet Venus is now well situated for evening observation. Data

of interest to observers are as follows:

Date 1938	Stellar Magnitude	% of Disk Seen Illuminated	Angular Diameter	Distance from Earth
July 1	—3.5	78	13″.8	113,600,000 mi.
Aug. 1	—3.6	66	16.7	92,662,000
Sept. 1	—3.9	53	22.3	70,189,000

Mars. Conjunction of Mars and the sun occurs July 24, 19^h.

Jupiter. Jupiter is in opposition with the sun August 21, 0^h. The opposition is not especially favorable, due to the planet's southerly declination of —13°.5 at opposition. The stellar magnitude at opposition is —2.4, and the polar diameter, 45″.8.

Saturn. Saturn is in western quadrature with the sun July 10, 15^h. By August 1, its easterly apparent motion ceases, the motion then becoming retrograde. The stellar magnitude is +0.8 on July 1, and +0.6 on September 1.

Uranus. Uranus is again observable. The planet is in western quadrature August 11, 2^h. The apparent motion becomes retrograde August 24. The planet is in conjunction with the moon August 18, 7^h 49^m, at which time Uranus will be situated 45′ to the south of the moon's center, or about one lunar diameter to the south of the southernmost point of the moon's disk. The apparent disk of Uranus at that time is 3″.5 in angular diameter. Positions of Uranus in right ascension and declination are listed below:

Date 1938	α h m	δ ° ′
July 1	2 57.2	+16 28
Aug. 1	3 1.0	+16 44
Sept. 1	3 1.7	+16 47

Neptune. Neptune is to be found in the evening sky. Observers are again reminded that in *Planet Notes* for March, 1938, a chart is given, showing the path of Neptune among the stars.

On July 31, 7^h, Neptune is in conjunction with Venus. Neptune will at that time be situated 26′ north of Venus, and 62′ north of the 6.4 magnitude star, 80 Leonis. The star, 80 Leonis, is indicated on the chart, referred to above, as well as the position of Neptune for August 1. At the time of the conjunction (7:00 P.M. C.S.T.), Neptune may be found from a setting on Venus, by means of a differential shifting of the observer's telescope in declination, through an amount equal roughly to one lunar diameter.

Asteroid Notes

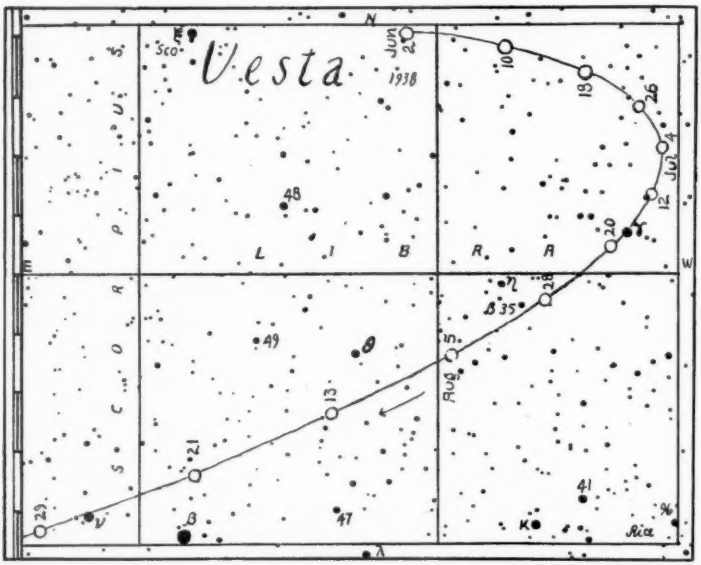
By HUGH S. RICE

The minor planet 3 Juno during the period June 10 to the end of September completes a horseshoe curve, the beginning of which was shown in our chart published in the preceding issue of this magazine. Passing just north of δ Ophiuchi on June 26 (when it is actually in the constellation Serpens Caput for a few days), it moves westward as far as R.A. 16^h 1^m at Decl. —4° 46′ on July 28, then moves southeast to R.A. 16^h 37^m and Decl. —10° 14′ on September 30. Magnitude of Juno changes from 10.0 on June 1 to 10.8 on September 30.

The asteroid 2 Pallas is much farther east than Juno. It moves eastward in June and July for a short distance in southeastern Pegasus, in a region of no bright stars just north of the "circlet" of Pisces. On June 10, its position is R.A. 23^h 27^m, Decl. +8° 5′, and the magnitude 9.6. On July 20 the position is

R.A. 23h 41m, Decl. +7° 35′, and magnitude 9.1. After that it moves southward and begins retrograde motion. Pallas will be in more convenient position in the late summer than early.

The best asteroid for observation at this time is 4 Vesta. Our chart shows, by



the small circles, the position of this object at 7:00 P.M., E.S.T., on the days indicated. Some close conjunctions with stars take place, notably with γ Librae on July 18. Detailed study of this "event" shows that at about 9:00 A.M. (E.S.T.) on that day Vesta passes by (northeast of the star, at a distance of 3′ of arc; it is of course invisible here at that hour, but when evening arrives in America (7:00 P.M., E.S.T.), the asteroid is directly east and 5′ away. This star, γ Librae, is a convenient guide star for locating Vesta in June and July. Magnitudes of the planetoid range from 5.9 on June 2 to 6.5 on July 20, and 7.0 on August 29.

Asteroid 1 Ceres is not in a good place for observation until later this year. The positions of Pallas were computed by Kahrstedt, those of Juno by Gondolatsch, and those of Vesta by Bawtree. We also give ephemerides of planets that can be picked up by, say, 6-inch home-made reflectors. They were computed at the German headquarters, the Astronomisches Rechen-Institut at Berlin-Dahlem.

EPHEMERIDES OF ASTEROIDS. FOR 0h U.T. EQUINOX OF 1950.

17 THETIS (9M.2)

		α h m	δ ° ′
June	7	17 37.8	−15 50
	15	17 30.3	−16 4
	23	17 22.9	−16 23
July	1	17 16.1	−16 47

324 BAMBERGA (8M.7)

		α h m	δ ° ′
July	1	20 6.0	−33 30
	9	19 57.9	−33 33
	17	19 48.5	−33 26
	25	19 38.8	−33 5
Aug.	2	19 29.7	−32 31
	10	19 21.5	−31 44

		85 Io (9M.9) α h m	δ ° ′			6 Hebe (7M.8) α h m	δ ° ′
June	15	19 14.9	— 2 29	July	9	21 4.3	— 8 52
	23	19 9.9	— 1 50		17	21 0.0	—10 2
July	1	19 3.7	— 1 25		25	20 54.4	—11 28
	9	18 56.9	— 1 17	Aug.	2	20 47.9	—13 5
	17	18 50.3	— 1 24		10	20 40.9	—14 50
	25	18 44.4	— 1 47		18	20 34.5	—16 35

Hayden Planetarium, American Museum of Natural History,
New York City, May 22, 1938.

Occultation Predictions

(Taken from the *American Ephemeris*)

Date 1938		Star	Mag.	IMMERSION Greenwich C.T. h m	IMMERSION a m	IMMERSION b m	IMMERSION Angle E from N °	EMERSION Greenwich C.T. h m	EMERSION a m	EMERSION b m	EMERSION Angle E from N °
Occultations Visible in Longitude +72° 30′, Latitude +42° 30′.											
July	9	ω Oph	4.6	4 26.6	—1.4	—0.5	72	5 43.4	—1.3	—1.8	286
	10	30 G.Sgr	6.2	23 35.9	0.0	—0.7	148	0 17.6	—1.9	+3.1	216
	11	μ Sgr	4.0	3 44.2	—2.0	+0.7	59	5 9.4	—2.2	—1.0	282
	18	22 Psc	5.8	6 21.5	—1.5	+1.6	76	7 37.7	—1.3	+1.9	225
Aug.	5	84 B.Sco	6.3	2 14.5	—1.7	—1.2	102	3 33.9	—1.1	—1.1	260
	6	116 B.Oph	6.3	2 25.4	—1.6	0.0	60	3 42.4	—1.8	—1.8	292
	9	267 B.Sgr	5.9	1 56.4	..	..	128	2 48.2	..	..	200
	15	51 Psc	5.7	9 49.1	—1.0	+1.7	28	10 50.5	—1.5	—2.0	282
	17	12 H¹.Ari	6.3	2 27.7	+0.4	+1.6	58	3 20.5	0.0	+1.3	264
	18	Uranus	6.1	6 15.8	—1.1	+0.9	105	7 12.2	—0.5	+2.6	216
	19	43 Tau	5.7	9 29.0	—1.6	+1.3	75	10 48.6	—1.9	+0.4	263
	20	*l* Tau	5.3	8 29.5	—0.7	+2.2	58	9 33.1	—1.5	+0.3	287
	21	64 Ori	5.2	5 57.3	+0.3	+1.0	94	6 48.7	+0.1	+1.3	261
	21	68 Ori	5.7	9 29.0	—0.9	+1.4	84	10 38.7	—1.4	+0.6	277
	23	30 B.Cnc	6.1	8 0.8	+0.1	+0.3	123	8 48.6	+0.1	+1.5	255
	31	λ Lib	5.1	23 29.0	—1.8	0.0	64	0 41.5	—1.7	—2.1	307
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′.											
July	9	ω Oph	4.6	3 50.5	—2.2	+0.3	71	5 16.4	—2.1	—1.5	294
	11	μ Sgr	4.0	3 2.1	—2.1	+1.6	64	4 27.9	—2.2	—0.2	288
	16	51 Aqr	5.8	11 18.7	..	..	340	11 30.7	..	..	320
	18	22 Psc	5.8	5 58.6	—0.7	+2.0	64	7 9.8	—1.1	+1.8	243
	20	π Psc	5.6	9 34.1	—1.4	+1.6	69	10 53.1	—1.6	+1.5	238
	24	372 B.Tau	6.1	9 58.4	0.0	+1.8	64	10 52.9	—0.6	+0.7	285
Aug.	5	84 B.Sco	6.3	1 38.2	—2.2	—0.5	105	3 8.8	—2.0	—0.8	266
	5	51 G.Sco	6.4	3 44.1	..	..	148	4 28.4	..	..	213
	6	116 B.Oph	6.3	1 44.6	—2.4	+1.0	62	3 7.9	—2.4	—1.3	300
	9	267 B.Sgr	5.9	1 25.3	..	..	136	2 10.9	..	..	203
	14	λ Psc	4.6	7 12.1	—2.9	—0.2	107	8 9.1	—0.6	+3.1	191
	15	51 Psc	5.7	9 25.5	—0.6	+3.5	9	10 17.6	—2.9	—2.2	292
	18	Uranus	6.1	6 1.3	—0.3	+1.3	90	6 58.6	—0.3	+1.9	234
	19	43 Tau	5.7	9 2.9	—0.8	+2.0	62	10 13.4	—1.6	+0.8	270
	20	*l* Tau	5.3	8 19.1	+0.1	+2.5	44	9 7.7	—1.1	+0.2	300
	21	68 Ori	5.7	9 14.8	—0.2	+1.6	75	10 15.0	—0.8	+0.8	282

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′.

July	9	ω Oph	4.6	2 44.8	−1.6	+0.7	102	4 13.2	−2.1	+0.2	282
	11	μ Sgr	4.0	2 17.9	−0.6	+1.1	98	3 31.2	−1.2	+1.2	267
	11	21 Sgr	5.0	10 28.8	−0.7	+0.1	52	11 35.7	−0.8	+1.5	276
	20	π Psc	5.6	9 5.0	−0.2	+2.2	43	10 5.4	−1.0	+1.1	269
Aug.	5	51 G.Sco	6.4	2 53.5	..	..	165	3 32.6	..	..	214
	13	6 G.Psc	6.2	8 56.7	−1.0	+1.7	125	9 30.1	..	..	170
	14	λ Psc	4.6	6 16.7	+0.5	+1.1	77	7 28.3	−1.1	+2.0	228
	18	Uranus	6.1	6 1.2	+0.4	+2.4	76	6 51.8	+0.3	+1.3	252
	19	43 Tau	5.7	8 48.6	..	..	37	9 33.9	−0.8	+0.3	296
	20	*l* Tau	5.3	8 28.2	+0.6	+1.7	9	8 43.3	..	..	337
	21	68 Ori	5.7	9 14.5	..	..	56	9 58.0	−0.2	+0.2	300

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Comet Notes

By G. VAN BIESBROECK

COMET 1938 *a*. After many unsuccessful attempts, PERIODIC COMET 1927 VI (GALE) has finally been recovered. Mr. L. E. Cunningham of Cambridge, Massachusetts, had established a series of ephemerides for this comet by varying the time of perihelion passage by 32 days either way from the date May 16, which he considered as the most probable. To such a change corresponded a range of five hours in the right ascension, which meant that a large area of the sky had to be searched for the expected visitor. Mr. Cunningham conducted the search with the 8-inch photographic refractor at Oak Ridge and his efforts were finally rewarded when he located the object on a plate taken May 1 and in a position slightly outside the 64 day range covered by the search ephemerides.

The discovery observation given in Announcement Card 445 of the Harvard College Observatory is as follows:

1938 May 1.24423 $17^h\,24^m\,2^s$ −13° 5′ (1950)

Total magnitude about 10.

Faint coma 100″ in diameter and central condensation 30″ in diameter.

The corresponding date of perihelion passage is near 1938 June 18.5, fully a month later than Cunningham's prediction and two months later than the one on which the ephemeris on p. 271 was based. The period comes out 11 years and 4 days.

The corrected ephemeris becomes:

	α	δ	M
	h m	° ′	
May 30	19 48	−30 28	8.3
June 7	20 47	−35 22	8.1
15	21 46	−38 34	8.1

showing that, while the comet will gain a couple of magnitudes up to the middle of June, its southern declination makes the position unfavorable for our latitudes.

At Williams Bay the comet was photographed on May 6 and examined visually on May 10. The total magnitude did not seem to be brighter than 11. It showed an almost stellar nucleus of 12^M very eccentrically situated in a coma extending to a length of 2′ in position angle 265° giving the appearance of short tail in a direction nearly opposite to that of the sun.

Since this is the first comet announced this year it receives the preliminary designation 1938 *a*.

Cloudy skies here have prevented further search for the expected PERIODIC COMET 1925 II (see ephemeris p. 271) which has already passed opposition unrecovered.

Williams Bay, Wisconsin, May 20, 1938.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The most important and best equipped expedition for the study of meteors that has ever been sent out was that from Harvard College Observatory to Arizona, which spent 22 months in intensive observations. The work was directly under the charge of Dr. E. J. Öpik, assisted by Dr. S. L. Boothroyd of Cornell, with an average number of four young men as assistants, the latter without previous experience in observing. It is understood that Boothroyd had no part in the particular phase of the work about to be discussed. The results, based upon 26,000 observations of 22,000 meteors on 366 nights, are being published by Harvard Observatory, most of the papers being written by Öpik.

It goes without saying that these papers, describing both the methods used and the results obtained, are being eagerly read by all interested in the subject. Hence a review of certain phases will be of value to the A.M.S. members and others. The general remark should be made that new methods, some most successful, were tried out and that results of high value have appeared. Further, statistical studies of the data, on a scale almost unique in meteoric annals, have been and are still being carried out by Öpik. Hence all meteor observers are under enduring obligations for the valuable results obtained, in so many lines, through the labors of this expedition and the mathematical skill of Öpik in the analysis of the data. Nevertheless progress in science can be truly attained by pointing out where improvements in practice or plans can be made, as well as by praising those things which seem beyond just criticism. As I have had wide experience both in the observation of meteors and in determination of radiants from work done by others, it is but natural that a study was made of the radiants obtained by Öpik from this immense mass of data.

First it should be said that the actual observations were made using reticules, which force the employment of only one eye at a time by the observer. I am convinced that this is inferior to that of directly plotting upon prepared star maps, in the ways often described in the A.M.S. instructions and elsewhere, since then one has the advantage among others of using both eyes. In partial explanation, Öpik probably thought that untrained observers would do better with reticules. I agree that such might be the case for the first few weeks, but men, working as often as this group did, should soon have acquired at least a fair accuracy with maps, and,

after some months, a very good accuracy. Hence I think that an error of judgment was made and that the analysis to follow will bear out the contention that the plotting based on the use of reticules must have been of inferior accuracy.

Referring now to *H. C. O. Circular* No. 388, Öpik described in the fullest detail his method of deriving radiants. Briefly they are based on ideas of probability—the discussion is far too involved for any review—and out of 2000 possible radiants that he first derives, he ends up with only 280 which, on *mathematical* grounds, are satisfactory to him. These will now be discussed.

It is impossible in the cases of many minor streams to find agreement among the best authorities as to whether their radiants have a real existence or not. However, for a few large streams, as well as for a good number of the minor, there is unanimity. I have hence chosen those known to everyone: Quadrantids, Lyrids, Eta Aquarids, Delta Aquarids, Perseids, Orionids, Leonids, and Geminids. As these appear in 8 out of the 12 months, an analysis of results based upon what Öpik found as to them should be a more than fair criterion for what he found for lesser radiants. To make things as fair as possible, I have taken the minimum rather than the maximum number of days during which each shower appears.

In order, during the Quadrantid period in 1931, 3 radiants were observed on 5 nights, no Quadrantid radiant appearing in list. In 1932, on 3 nights, 3 radiants, 2 being Quadrantids.

Lyrids: in 1932, 2 nights, 2 radiants, no Lyrid radiant. In 1933, 6 nights, 10 radiants, of which 3 were Lyrid radiants.

Eta Aquarids: in 1932, 4 nights, 4 radiants, of which 3 were Eta Aquarid. In 1933, 1 night, 1 radiant, 1 Aquarid.

Delta Aquarids: (As the radiant for these is none too well determined, I have taken all *possible* cases in Öpik's list as Delta Aquarids.) 1932, 5 nights, 12 radiants, of which 4 were Delta Aquarid. 1933, 4 nights, 4 radiants, of which 2 were Delta Aquarid.

Perseids: 1932, 12 nights, 32 radiants, of which 9 were Perseid.

Orionids: 1931, 7 nights, 11 radiants, of which 2 were Orionid. 1932, 9 nights, 17 radiants, of which 1 was Orionid.

Leonids: 1931, 7 nights, 14 radiants, of which 5 were Leonid. 1932, 4 nights, 4 radiants, of which 1 was Leonid.

Geminids: 1931, 4 nights, 3 radiants, of which 1 was Geminid. 1932, ??? nights, no radiants.

In the table which follows will be given in order the Öpik radiant numbers, dates, right ascensions and declinations, and number of meteors he apparently used in deducing each radiant. Then the right ascensions and declinations for these same radiants when available from other authorities or other notes.

	—Date—								
No.	Year	Mo.	Da.	α	δ	Meteors			
212	1933	1	2	230°	+47°	82	231°	+51°	Denning, G. C.
213		1	3-4	225	+45	16			
241		4	21	275	+30	55	272	+34	Denning, G. C.
243			22	267	+31	25			
244			23	260	+30	11			
89	1932	4	30	338	− 5	16			
91		5	3	335	− 5	11	332	0	Olivier
92		5	4-5	330	− 4	27	334	0	Olivier
249	1933	5	3	338	+ 3	17	332	0	Olivier

No.	—Date— Year	Mo.	Da.	α	δ	Meteors			
111	1932	7	28-29	343°	— 6°	43			
113			30	345	— 8	27			
114			31	344	— 6	20			
121		8	1	341	—16	70	340°	—12°	Denning, G. C.
276	1933	7	25	339	—11	28			
277a			29-31	336	—11	33			
116	1932	7	31	37	+53	45	32	+54	A. King
124		8	3	30	+49	19	36	+56	A. King
129			4-5	42	+55	29	37	+56	A. King
130			6	44	+63	40	39	+56	A. King
133			7	45	+57	67	41	+56	A. King
134			8	39	+54	51	42	+57	A. King
135			8	35	+67	20	42	+57	A. King ?? if Perseids
139			10	45	+57	224	44	+57	A. King
142			11	45	+57	291	46	+57	A. King
14	1931	10	16	95	+16	37	90	+15	R. A. McIntosh
15			20-22	93	+14	69	93	+15	R. A. McIntosh
171	1932	10	27-28	101	+17				
29	1931	11	14	148	+12	36			
31			16	152	+22	377			
34			17-18	140	+15	32	151	+22	Denning, G. C.
36			17-18	150	+36	25			
40			19	150	+20	12			
191	1932	11	12-17	150	+25	59			
46	1931	12	12	100	+34	27	112	+32	A. King

A glance at this table will show that a large number of the Öpik positions are far from those generally accepted as correct. Not only that, but in the cases of the Quadrantids, Lyrids, and Eta Aquarids he has the right ascensions of his radiants *decreasing* day by day, which is conceded to be exactly opposite to both past observations and theory. Further it is obvious that Nos. 34 and 36 of the Leonid group could be averaged into one to get a radiant near the true position. In fact, as this list contains more favorable cases than the average, the whole of the 280 radiants must be received with serious suspicion as to their value. Such a result must have causes. These may be sought, first in an inferior method of observing, but I do not think this can possibly explain such abnormal results. I can only assign them therefore to a purely *mathematical* way of treating data when a graphical one, with proper safeguards, has been generally conceded by the best observers to be the proper procedure. This opinion is fortified not only by the inaccurate positions found in so many cases, but equally from the fact that *no* radiants whatever appear for these major streams on so many of the nights when they were certainly in activity and when the full force of observers was on duty. This is especially and startlingly true for the Orionids and Geminids, which cannot be missed. A more practical handling of the data, without being handicapped by so many theoretical barriers would without doubt have been radiants for these missing nights also. Again fairness to Öpik leads me to say that he preferred to retain only radiants that came up to certain mathematical specifications and deliberately rejected 1720 others which did not. One cannot say, without an examination of the rejected list, how much of value was lost. But if there is any department of astronomy in which good judgment on the part of the computer, rather than rigid rules, is necessary, it is in dealing with meteors. Further, all good observers are in full agreement that immense radiant areas for a stream mean not reality but poor observations. Hence any method whatsoever that allows the inclusion of very discordant paths whose projections may miss the radiant by very

many degrees cannot give results in which others have confidence. In No. 2, page 2, Öpik says his term radiant refers to "group radiant." This, however, in the final analysis is only a play on words: he either gets *the* (approximately) true radiant, *i.e.* (uncorrected) direction in space from which the meteors in question come in parallel paths, or he does not. His remarks as to former observers, which are such as to include all of whom I have knowledge, indicate that he has a poor opinion of radiants derived in the past. But for most of the streams, discussed above, the most critical person cannot claim that he doubts their radiants are quite well determined, some of them having been checked by photography. His case is also not strengthened by implications in such expressions, referring to other observers, as: ". . . some observed meteors were arbitrarily rejected because they did not agree with the observer's expectation. . .," and: ". . . the limit of 2° is rather close . . . for . . . an unprejudiced observer." Others could be quoted in similar vein. Finally, Öpik himself states, page 4, ". . . highly accurate positions of individual radiants cannot be expected from the Arizona results . . ." But the question may still be asked in all fairness, despite his reasons given in the paper, *why*, if the work was good, good radiants could not be found therefrom, as they can be from the work of dozens of other observers?

Letters have been exchanged with Mr. C. W. Gartlein, Department of Physics, Cornell University, Ithaca, New York, asking the coöperation of the A.M.S. in an auroral program. This help I trust the members will gladly give him. He is to furnish the proper blanks and instructions, on request. The work will include a study of aurorae in low latitudes, especially time and place of occurrence, color, forms, and times of sudden changes in these forms. As aurorae do not occur very often at any given place in our country, such coöperation should not be burdensome in time or effort.

Finally, our members are again urged to make the most of the excellent meteor rates and warmth of the summer nights. Coöperative programs for heights are especially desired. Please write long in advance for supplies of maps, blanks, etc., and for any advice or instructions a special group may desire.

Flower Observatory, Upper Darby, Pennsylvania, 1938 May 10.

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD,
Department of Astronomy, University of California at Los Angeles

President of the Society: H. H. NININGER, Colorado Museum of Natural History and American Meteorite Laboratory, Denver

Secretary of the Society: ROBERT W. WEBB, Department of Geology, University of California at Los Angeles

A Proposed Curriculum in Meteoritics for College Students

By FREDERICK C. LEONARD

ABSTRACT

A "major" or curriculum in meteoritics, leading to the bachelor's degree in colleges and universities, is outlined. It is recognized that a major in meteoritics would consist of a "combination major" in astronomy and geology, calling for an extensive preparation in the form of certain specified "lower-division" courses in

chemistry, geology, mathematics, and physics, as well as 15 "upper-division units" in astronomy and 10 "upper-division units" in geology, for the major proper.

The time will doubtless come and is probably not far distant when college students will want to specialize, or—to use the technical term—to "major," in meteoritics, just as they now major in astronomy, geology, and other physical sciences. Already, in the Department of Astronomy of the University of California at Los Angeles, we have introduced a one-semester (*i.e.* an academic-half-year) course in meteoritics (*v. C.S.R.M., P. A.*, **45**, 507, and *ib.*, **1**, Fasc. 3, 57, 1937). This course was taken for the first time last fall by fifteen students, of whom nine were majoring in geology, five in astronomy, and one in botany. The course is scheduled to be repeated next fall and promises again to have a good-sized enrolment, constituted largely of the registration of major students from geology. Since meteoritics is a hybrid science, or, as it is sometimes called, a border field between the territories of astronomy and geology (mainly mineralogy and petrology), it follows that a major in meteoritics would have to be what we should term at the U.C.L.A. a "combination major" of astronomy and geology; accordingly, it would require of the student most of the preparation demanded in each of these subjects.

After consultation with my colleague Dr. Robert W. Webb of the Department of Geology of the U.C.L.A. and the Secretary of the Society for Research on Meteorites, I have formulated the following proposed curriculum leading to the bachelor's degree, with a major in meteoritics, in the College of Letters & Science of the U.C.L.A. There is no reason why this curriculum, or its equivalent, should not be instituted in any college or university with departments of astronomy, geology, and related sciences.

At this point I shall have to define a few technical terms in common use at the U.C.L.A. and other universities. By a "major" is meant a coördinated group of courses aggregating not more than 30 and generally 24 "upper-division"—*i.e.* "senior-college" or third- and fourth-year—"units" in a single department or in two or three closely allied departments, acceptable toward the bachelor's degree in the principal or major subject of the student's choice. The "unit" value of a course indicates the number of times per week the course meets during a "semester" (or an academic half-year) of approximately 18 weeks; *e.g.*, a 1-unit course meets once a week throughout a semester, a 3-unit course three times, and a 5-unit course five times. Every major proper presupposes as preparation certain "lower-division"—*i.e.* "junior-college" or first- and second-year—courses in the major department "and/or" in cognate departments. These preparatory courses should be completed, if possible, before upper-division major work is undertaken, and, in any event, they are essential requirements for the completion of the major. 120 units of work, of which at least 36 must be in upper-division courses, are required for the bachelor's degree at the U.C.L.A.

Following is the proposed curriculum or major in meteoritics—which, as has been explained, would be in effect a "combined major" in astronomy and geology—as it would probably work out at the U.C.L.A. I have included both the number and the unit value of each course mentioned, as listed in the current *General Catalogue* of the University. Numbers under one hundred are used for lower-division courses and numbers between one hundred and two hundred, for upper-division courses. It is hoped that this proposed major in meteoritics may be found helpful, or at least suggestive, to any institutions which, if not at the present time, may, at some future date, contemplate the possibility of inaugurating a curriculum

in meteoritics as an integral part of their major offering toward the bachelor's degree in their liberal-arts or technical colleges.

THE PREPARATION FOR THE MAJOR IN METEORITICS

(1) *Chemistry:* One academic year (*i.e.* two semesters) of general chemistry (Chem. 1A-B: 10 units). Recommended to be taken in the upper division, but not required: a year of quantitative analysis (Chem. 6A-B: 6 units).

(2) *Geology:* A year of general geology (Geol. 1A-B: 6 units) and of general mineralogy (Min. 3A-B: 6 units).

(3) *Mathematics:* One semester each of college algebra (Math. 8: 3 units), plane trigonometry (Math. C: 2 units), and plane analytic geometry (Math. 3A: 3 units), and two semesters of calculus (Math. 3B and 4A: 6 units). Recommended, but not required: one semester of spherical trigonometry (Math. F: 1 unit) and (to be taken, presumably in the upper division) a third semester of calculus (Math. 4B or 109: 3 units).

(4) *Physics:* A year of general physics (Phys. 2A-B: 8 units); or, better, two years of general physics (Phys. 1A-B-C-D: 12 units).

THE MAJOR PROPER IN METEORITICS

(1) *Astronomy:* A year of general astronomy (Astr. 103A-B: 6 units) and of astrophysics (Astr. 117A-B: 6 units) and a semester of meteoritics (Astr. 118: 3 units). [The course in meteoritics may eventually be expanded into a 6-unit, year course, as Astr. 118A-B, and doubtless will be, if and when a major in meteoritics is offered at the U.C.L.A.] Total number of upper-division units in astronomy: 15.

(2) *Geology:* A semester of general petrology (Geol. 103: 4 units) and a year of optical mineralogy and petrography (Min. 109A-B: 6 units). Total number of upper-division units in geology: 10. Total number of upper-division units in the meteoritical major (= the total number of upper-division units in both astronomy and geology): 25.

Observations Pertaining to the Times of Meteorite Falls* [Abstract]

By RALPH I. MEEKER, JR.,
4100 Zenobia Street, Denver, Colorado

Such observations as are made in this paper concern themselves in the main with two questions which I have attempted to answer:

(1) Do meteorites of the same type make a cyclical appearance?

(2) Do any types of meteorites fall in particular seasons or at particular times of the day?

It is important to note here that Farrington, in Chap. IV of his *Meteorites* (1915), makes a study similar to the one I have made, but with meteorites taken as a whole, and not according to specific types. As far as I know, my study is the only examination of times of fall according to types attempted so far.

Using falls as taken from G. T. Prior's *Catalogue of Meteorites* (British Museum, 1923), not including the *Appendix* (1927), probably the most complete record of meteorites in existence today, I arranged the 405 falls of stones given there in chronological order from 1800 to 1920, and further differentiated them according to types, utilizing a slightly modified Rose-Tschermak-Brezina classifi-

*Read at the Fifth Annual Meeting, June, 1937.

cation. Those which were suitable were then plotted according to years, months, and hours, on large charts.

A close examination of the year-type chart failed to reveal any regular recurrence of any given type of fall. A search of the month-type and hour-type charts showed a few slight concentrations of certain types in some months and hours, but these concentrations can have little significance, since they occur along with steady sprinklings throughout the year and the day. This fact suggests that the concentrations are accidental, on account, perhaps, of better conditions of observation at certain times. The reasons for these conditions are discussed in some detail in the main body of the paper and in Chap. IV of Farrington.

Thus it appears on the basis of this study that:

(1) Meteorites of the same or given types do *not* make a cyclical appearance.

(2) *No* given types of meteorites fall in particular seasons or at particular times of the day.

These conclusions by no means *prove,* however, that no periodicity of the kinds sought exists, since the data used are likely to be unreliable in many cases and are certainly incomplete, in view of the number of unrecorded falls arriving on the earth.

Frequency and Distribution of Observed Meteorite Falls* [Abstract]

By JULIA LOLA SMEAD,
Colorado Museum of Natural History, Denver

1. From resources at my disposal, I have located records of 536 witnessed meteorite falls. Of these, 4 occurred in Australia and New Zealand; 131 in Asia (exclusive of Siberia); 9 in Asia Minor; 253 in Europe and Siberia; and 31 in Africa. In the western hemisphere, 107 observed falls have occurred; 92 in North America (3 in Canada, 79 in the United States, 9 in Mexico, and 1 in Costa Rica); 14 in South America; and 1 only in the Pacific Ocean area (on the Hawaiian Islands).

2. India, with 102 witnessed falls, has the greatest number of observed meteorite falls recorded for a single country; the United States is second with 79; France third with 53; Germany fourth with 24; and Spain fifth with 23.

3. Apparently there is no connection between years of observed falls and localities, although in Europe there was a slight tendency for these falls to occur in groups with a period of 5 years.

4. The greatest frequency of witnessed falls occurred in 1868, when 11 meteorites were seen to fall in various parts of the world; on the other hand, 1832 was the last year for which no observed fall has been recorded.

5. The number of observed falls in each country has been compared with the population per square mile, but no related facts or ratios have been established.

6. Longitude apparently does not affect witnessed falls, but, perhaps on account of the smaller land area and the lesser population in the southern hemisphere, northern latitudes have received the greater share of observed falls, mainly from latitude +8° to +68° in the eastern hemisphere and from latitude +26° to +48° (approximately the boundaries of the United States) in the western hemisphere.

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*Read at the Fifth Annual Meeting, June, 1937.

Recent Lists of Meteorite Falls and Statistics Concerning Meteorites

Attention is called to the "Meteor News" in the *Jour. Roy. Astr. Soc. Canada*, **32**, No. 4, 195-206, April, 1938. This contains a list of the meteorites, 95 in number, of the Soviet Union and territory formerly Russian, as compiled by I. S. Astapowitsch, and two notes entitled "Recent Lists of Meteorites" and "Meteorite Statistics," by P. M. Millman. The former note (by Millman) contains two full-page preliminary maps showing the location of the meteorites of the U.S.S.R., in both Europe and Asia, and an enumeration of 5 miscellaneous meteorites reported in the years 1936-38; the latter, a list of the 39 meteorites (3 uncertain) of the Japanese Empire (according to I. Yamamoto, *Kwasan Obs. Bull.*, No. 306, 1935), a map showing the geographical distribution of these Japanese meteorites, a table of 37 meteorites in F. Heide's list (*Fortschritte der Mineralogie, &c.*, **21**, 225, 1937), not included in the lists of H. H. and Addie D. Nininger (*Our Stone-Pelted Planet*, appendix, 1933, and *C.S.R.M., P.A.*, **45**, 449-54, and **1**, No. 3, 41-5, 1937, respectively), a table of the distribution of 1,204 meteorites, and, finally, a graph showing the frequency of the meteorite falls of the world by decades. The information summarized in the aforesaid "News" will be found of the utmost value to students of meteoritics.

Delegate Appointed to the 1938 I. A. U. Meeting at Stockholm, Sweden

The Executive Committee, with the approval of the Council, has appointed Dr. Frederick C. Leonard, the Ex-President and Editor of the Society, to serve as its official representative at the triennial meeting of the International Astronomical Union and its Commission No. 22 (that on meteors *etc.*), at Stockholm, Sweden, August 3-10, 1938. Dr. Leonard received word in April of his coöptation for membership on this Commission. He will sail for Europe early in June and will be abroad, mainly in England, during most of the summer, returning to Los Angeles about the middle of September.

Notice Concerning Abstracts of Papers

On account of the limited amount of space available in these CONTRIBUTIONS and in the interest of efficiency, the Publications Board of the Society has adopted the following rule, to be effective henceforth:

"Every paper reporting scientific results which exceeds a printed page in length and which is submitted for delivery at a meeting of the Society and/or for publication in its CONTRIBUTIONS, shall be accompanied by an *abstract* which may be published in the CONTRIBUTIONS in lieu of the paper, if the latter is too long or otherwise unsuitable for inclusion therein in full, or at the beginning of the paper if the latter is accepted for publication in full. The abstract, which should be prepared by the author of the paper, should be as brief as possible but at the same time should contain all the essential results of the investigation or study reported on in the paper. Only papers which, on account of the nature of their contents or their brevity, in the discretion of the Editor do not come under this rule, need not be accompanied by an abstract."

Contributors are respectfully requested kindly to comply with this rule in future.—EDITOR.

Notes from Amateurs

The New Haven Amateur Astronomical Society

May 14 was a big day for the New Haven Amateur Astronomical Society because at 3:15 A.M., twenty-five members assembled on the Yale Observatory lawn to observe the total eclipse of the moon in a beautiful clear sky. Many of the members brought their telescopes with them and there was an array of instruments, consisting of two 6-inch reflectors, one 4-inch refractor, one 4-inch reflector, two 4-inch R F T, and several binoculars, and all had an opportunity to view the eclipse to advantage. After totality the telescopes were turned upon Jupiter and its four satellites. At 5:30 the group enjoyed breakfast together in a downtown restaurant and the eclipse party was over.

In the evening the regular meeting was held with its usual good attendance and enthusiasm. Reports were made concerning the work of the Telescope Making and Meteor Observing Groups, both being active and successful.

Mrs. Rademacher described her work in Variable Star Observing, stating that she had reported 130 observations since December last and found her work intensely interesting.

Dr. Brouwer of the University as speaker of the evening addressed the group on the "Rotation of the Milky Way System" and said in part, "Until about twenty years ago the study of the galactic system was concentrated upon the stars of the local system in which the sun occupied a nearly central position. Shapley's studies of the globular clusters introduced into astronomy a system of much larger dimensions of which the center is at least 30,000 light-years away in the direction of the constellation Sagittarius. No link between these two separate fields existed before rotation of the galactic system was established from observational evidence by Oort in 1927. The local system must now be considered as part of a much larger star system of which the center coincides with that of the system of the globular clusters.

"It is now possible to explain without any artificial assumptions a number of known features of the local system; to take an example, that of Kapteyn's star streams. While solving many of the older problems, the new conception of the Milky Way System has introduced a number of new problems, some of which are still far from being solved."

Dr. Brouwer illustrated his address by numerous blackboard sketches and lantern slides.

F. R. BURNHAM, *Secretary.*

820 Townsend Avenue, New Haven, Connecticut.

Amateur Astronomical Society of Los Angeles

The regular monthly meeting of the Amateur Astronomical Society of Los Angeles was held Thursday evening, May 12, 1938, at the clubhouse, 2606 W. 8th St. After several announcements, including a reminder of the lunar eclipse to take place the following evening, and announcement of an observing excursion for the end of the month, the Chairman introduced the speaker of the evening, Dr. William H. Christie of the Mount Wilson Observatory.

Dr. Christie spoke on the subject "Sounding Space," illustrated with a number of new lantern slides. Among these were several recent photographs of the Mount Wilson road, which has been closed to the public because of the heavy

damage done by the recent rain. The road will probably be ready for use in about a month, although nearly wiped out in several places. The speaker explained the various methods of measuring astronomical distances, such as trigonometric and spectroscopic parallaxes and determination of the periods of Cepheid variables. He demonstrated the different ways of measuring the brightnesses of the stars photographically, the out-of-focus method, by the use of an objective grating, and with the Schraffierkasette. The latter mechanism, which owes its development to Dr. Christie, is a camera attachment for a telescope which moves the photographic plate by clockwork in such a manner as to produce, instead of a point image on the photograph, a small square, much like an out-of-focus image, the density of which can be determined very accurately, thus measuring the magnitude of the star. The advantage of this over the extra-focal method is that imperfections in the lens or mirror, which are glaringly apparent when the image is out of focus, and tend to diminish the accuracy, are entirely eliminated by use of the moving-plate camera.

Dr. Christie also showed many lantern slides of nebulae and other objects that are seldom seen, including the discovery plate of Hubble's Comet, found at Mt. Wilson last year, and also several photographs made by Dr. Baade in infra-red light, of star fields in the Milky Way, in which fifty times as many stars were visible on the red plates as on blue-sensitive photographs, due to the fact that the galactic obscuring clouds are transparent in light of the longer wave-length.

The meeting adjourned at 10:00 P.M. There were fifty members present.

GEORGE HERBIG, *Secretary.*

2606 W. 8th St., Los Angeles, California, May 14, 1938.

The Cleveland Astronomical Society

Western Reserve Academy at Hudson, Ohio, extended an invitation to the Society to be present at a lecture by Dr. Harlow Shapley during the Loomis Observatory Centennial on Saturday, May 7, at 8:30 P.M. The lecture on the topic "Sidereal Organizations" was held in Cutler Hall in the presence of a large audience of visiting astronomers and invited members of astronomical societies from the surrounding area. The lecture dealt with the newly observed intergalactic super-clusters which appear unusual both as to size and location. Undoubtedly we will have to revise our ideas again about the structure of the universe. He also spoke of the so-called "windows" in our own galaxy through which we are able to look out into interstellar space. It appears that inter-galactic clusters similar to the one in the constellation Sculptor may be common. A few years ago it seemed as if we might glimpse some plan of order in the universe but it now seems that the universe does not consist of galaxies scattered around in a more or less regular plan but that there are many smaller or at least different organizations of stars in space. The lecture was delivered in the well-known fine Shapley manner. Astronomers seen at the meeting were Dr. Otto Struve, Dr. J. J. Nassau, Dr. Plaskett, Dr. N. T. Bobrovnikoff, Dr. D. B. McLaughlin, Dr. Donald H. Menzel, Dr. Milham, Dr. Dustheimer, and others. The celebration of the Centennial closed Sunday morning with a Chapel Service at which Professor Dayton C. Miller of Case School of Applied Science spoke on "The Service of Science in the World of Today." Mr. R. H. Cleminshaw kept things moving at all times. Professor Curtis of Michigan ran some motion pictures of sun prominences which were most unusual. They showed great masses of gaseous material falling upon the surface of the sun apparently from the upper regions of the atmosphere. No explanation as yet.

Hudson is a beautiful old town reminding one of New England. It is also the home of Lincoln Ellsworth, the polar explorer. This family made possible the restoration of the old buildings and ground to their present fine state.

14 Lincoln Drive, Cleveland, Ohio. DON H. JOHNSTON.

A Power Formula for Planetary Distances

Some one has said that planetary progression laws impress no one but their authors. A few are complicated and fail to induce readers to exert mental effort over them; others give distance errors so much greater than Bode's law—sometimes as high as 25 per cent—that no reason is seen for a substitution. We are sometimes told, however, that the distances obtained are for the remote past and that schemes giving close to present day values should be looked upon with suspicion. Evidently then the various laws are for different periods in the past.

"Small integers" have a charm for the law-propounder, especially as varying bases for a constant power or varying powers for a constant base. Bode's is a "small integer" power-law. It may be written

$$a + bc^n = d,$$

where $a = 0.4$, $b = 0.3$, $c = 2$, and d is the distance from the sun in astronomical units. The exponent n has a value of negative infinity for Mercury, 0 for Venus, 1 for the earth, 2 for Mars, etc.

A few years ago a power scheme was proposed by me (P. A., June-July, 1931) which probably has little right to be called a progression law. The term "formula" is perhaps more fitting. Orbital eccentricities, known of course to be changing slightly from year to year, figure somewhat in the scheme. However, the use of the present eccentricities gives values so close to present distances as to be rather surprising. This present paper is an attempt to approach the formula from a slightly different angle and to show more convincingly its accuracy.

The table below gives values used in the calculations that follow. Mercurian units, M.U., are distances from the sun in terms of Mercury's distance as the standard unit. Mass is in terms of the sun's as unity.

	n	Distance in M.U.	Eccentricity, E	Mass
Sun				1.000000000
Mercury	0	1.0000	0.20562	0.000000167
	1	.....	.....	.....
Venus	2	1.8686	0.00680	0.000002451
Earth	3	2.5833	0.01674	0.000003036
Mars	4	3.9362	0.09335	0.000000323
Ceres	6	7.1488	0.07653	0.000000000
Jupiter	8	13.440	0.04840	0.000954790
Saturn	10	24.642	0.05576	0.000285583
Uranus	12	49.576	0.04715	0.000043727
Neptune	14	77.682	0.00856	0.000050761
Pluto	15	101.93	0.24852	0.000002819
	16	.....	.....	.....
			Total	1.001343657

The introductory formula used is $(e/a)^n = d$. Here e is the Napierian base of logarithms (2.71828...), a is a constant, n is a series of integers, and d is the distance from the sun in M.U.

Let us first substitute in the formula the values of e, n, and d given in the table above and treat a as the unknown. Solution for each planet will give us the needed value of a to give exact correct distance. In the column headed a_1 in the

table below we find the results. If carried to only one decimal place, all, with the exception of Mars, will equal 2.0. Two places will still give Pluto 2.00. The 2.00 will fit Mercury also although any value will with the zero exponent. Both planets have "very high" orbital eccentricities. In rather "contradictory agreement," the low eccentricities of the earth, Venus, and Neptune also require rather high values of a; the medium and about equal values of E for Jupiter and Uranus need about the same intermediate a; the high E of Mars requires a low a.

It seems then that some sort of direct addition of E to our formula might bring the needed values of a for all the planets very near to 2.00. But we see that Pluto needs almost no addition. In all calculations hereafter, E will be omitted where Pluto is concerned. The "very high" eccentricities of Mercury and Pluto will be discussed later.

Next let us try the formula

$$(\overline{e+E}/a)^n$$

and again solve for a. The needed values are shown in the column headed a_2. To two decimal places, the only values are 1.99, 2.00, and 2.01. Order is rapidly developing.

Kepler's third law is a trifle more exact when the masses of the sun and planets are worked into his formula. Let us change our formula to

$$(\overline{em+E}/a)^n = d.$$

Here, m is a relatively insignificant factor, the total mass of the solar system less that of the planet under consideration, the mass of the sun taken as unity. Note the needed values of a under the column a_3. The results are very striking.

	a_1	a_2	a_3	
Mercury	(2.000)	(2.000)	(2.000)	= 2.00
.....	.....	.....	.....	....
Venus	1.989	1.994	1.996	= 2.00
Earth	1.981	1.993	1.996	= 2.00
Mars	1.930	1.996	1.999	= 2.00
Ceres	1.959	2.014	2.016	= 2.02
Jupiter	1.965	1.999	2.000	= 2.00
Saturn	1.973	2.014	2.016	= 2.02
Uranus	1.964	1.998	2.000	= 2.00
Neptune	1.992	1.998	2.001	= 2.00
Pluto	1.997	1.997	2.000	= 2.00

It thus apears that with a given a value of 2, the first member of our complete equation should give planetary distances very nearly correct in Mercurian units. The only possible exceptions are Ceres and Saturn. Ceres, however, is only one of the asteroids so the fact that it comes as nearly falling in line as it does is rather surprising. It will be found later that Saturn actually is rather unruly.

In the table below we treat d as the unknown. We are now ready actually to test how correctly our formula will give present distances. The first member now is

$$(\overline{em+E}/2)^n$$

The results are in M.U. These are changed to the more familiar A.U. by dividing each result by 2.5833, the earth's mean distance in M.U. The third column of figures gives the accepted values of the distances and the last column, the percentages of error. Although the base

$(\overline{em+E}/2)$

is slightly variable, yet for brevity it will hereafter be designated by K.

		Derived Distances M.U.	Derived Distances A.U.	Correct Distances A.U.	Error
Mercury	$K^0 =$	1.000	0.387	0.387	0.0%
.....	K^1				
Venus	$K^2 =$	1.862	0.721	0.723	0.3%
Earth	$K^3 =$	2.568	0.994	1.000	0.6%
Mars	$K^4 =$	3.926	1.520	1.524	0.3%
Ceres	$K^5 =$	7.505	2.906	2.767	5.0%
Jupiter	$K^6 =$	13.45	5.207	5.203	0.1%
Saturn	$K^{10} =$	26.63	10.31	9.54	8.1%
Uranus	$K^{13} =$	49.60	19.20	19.19	0.1%
Neptune	$K^{14} =$	78.10	30.23	30.07	0.5%
Pluto	$K^{15} =$	101.8	39.41	39.46	0.1%
.....	K^{16}				

Although Ceres' error of 5.0% seems great in comparison with the predominance of small errors in the table, yet if carried to only one decimal place the derived and correct values, 2.9 A.U. and 2.8 A.U., compare rather favorably.

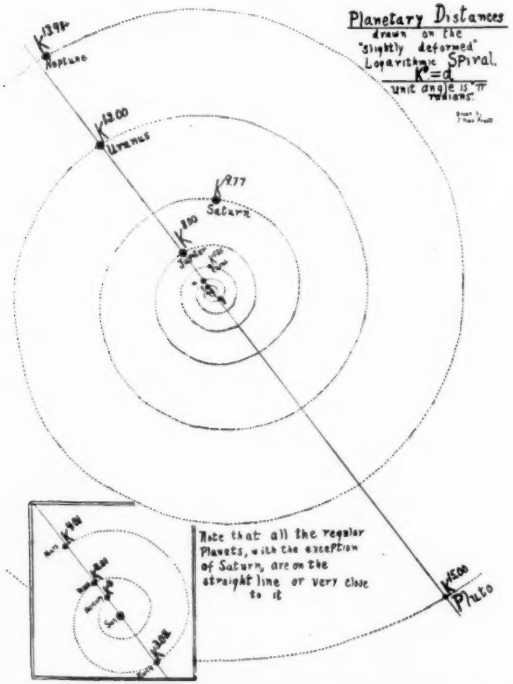
Omission of Pluto's eccentricity in the calculations has been mentioned previously. $(em/2)^{15}$ M.U. gives almost the exact distance of this planet. It was said that when E is "very high" it is omitted. This looked as though a special case was invented for Pluto. Mercury also has a "very high" orbital eccentricity but, since $K^0 = 1.000$ no matter what the value of K, it makes no difference whether E is omitted or not in the way the formula has been used so far. But there is a way to show that the same rule applies to both Mercury and Pluto. We may raise the values of the exponents of a few of the planets at the first of the list by 1, thus giving Mercury, Venus, and the earth exponents of 1, 3, and 4 instead of 0, 2, and 3. (We get into trouble if we go too high in the list.) We then see that if Mercury's E is used, results will be in great error while if omitted they are almost exact. The table below illustrates this. The first column of figures is changed to M.U. by dividing by 1.36097. Dividing again by 2.5833 gives the distances in A.U.

			Derived A.U.	Correct A.U.	Error
Mercury	$(em/2)^1 =$	1.36097	0.3871	0.3871	0.00 %
Venus	$(\overline{em+E}/2)^3 =$	2.5398	0.7224	0.7233	0.12 %
Earth	$(\overline{em+E}/2)^4 =$	3.5159	1.00002	1.00000	0.002%
.....					
Pluto	$(em/2)^{16} =$	138.54	39.405	39.457	0.13 %

As a last test of this scheme, let us see how nearly the "simple integer" idea really applies to the exponents. Perhaps comparison with the well-known Dufton law of squares will help to make this clear. The Dufton progression law, $n^2 = d$, states that the distances of the planets are closely proportional to the squares of small integers. These integers from Mercury to Pluto—when the earth's distance is taken as the standard—are 3, 4, 5, 6, 8, 11, 15, 22, 27, and 31. However, calculation shows that for correct planetary positions the squares needed actually are those of 3.11, 4.25, 5.00, 6.17, 8.32, 11.41, 15.44, 21.90, 27.42, and 31.41. The numbers 12, 16, 28, and 32 will give results very nearly as accurate as 11, 15, 27, and 31. If Mercury's distance is taken as the standard, the list looks slightly better but three of the "simple integers" have to be changed to 21, 26, and 30.

The table below shows the needed values of n to give correct distances in $K^n = d$. Most of them come very nearly to being "simple integers." The arrangement of powers is fairly regular. Starting with 0, all the even powers up to 14 are used with 3 and 15 filling in two of the blank spaces.

	$n = \log d / \log K$		
Mercury	0.00	=	0.0
.....	1.00		
Venus	2.01	=	2.0
Earth	3.02	=	3.0
Mars	4.01	=	4.0
Ceres	5.85	=	5.9
Jupiter	8.00	=	8.0
Saturn	9.77	=	9.8
Uranus	12.00	=	12.0
Neptune	13.98	=	14.0
Pluto	15.00	=	15.0
.....	16.00		



The accompanying diagram shows the planets arranged, at their proportional mean distances from the sun, on a "slightly deformed" logarithmic spiral. The distortion, of course, is caused by the slight variability of the base K. The unit angle is π radians, or half a revolution. When n has integral values, the planets will fall on the straight line. Saturn is the only regular planet which is much out of place.

We may now state our scheme rather definitely:

"The mean distances of the planets, to a close approximation, are equal to integral powers of a slightly variable base, made up principally of $e/2$ with small corrections for individual masses and orbital eccentricities. The values of the powers run consecutively from 1 to 4 but by even numbers only from 4 to 16. Whenever an eccentricity is very high—0.20 or more from data at hand—, this quantity is omitted in the calculations and the power is set back one place—Mercury from 1 to 0 and Pluto from 16 to 15. The exponent 0 gives Mercury the distance of unity. All following mean distances are in Mercurian units."

Let us now note a few important facts concerning the formula:

(1) The required values of n for all the principal planets, with the exception of Saturn, are actually extremely close to integers; not simply "somewhat" nearer one integer than another as in some schemes.

(2) In most cases the small percentages of error will be absolutely spoiled if values of E other than those of the planets concerned are used. Venus with Mars' eccentricity and mass will give an error of 6.0%; Mars with Venus', 12.0%; Uranus with Neptune's, 15.0%; Neptune with Uranus', 21.0%; and Neptune with Mars', 65.0%. Compare these with the small percentages of 0.1% to 0.5% in the table. Thus a rather insignificant error in the base becomes very large when raised to a high power. A final quite accurate value of d implies almost perfect accuracy in the base.

(3) No unusual constants are used to make the results look familiar. e, 2, and the part of m which has to do with the total mass of the solar system are taken as they are without changes. E, and m as a whole, are variables. E is a very important variable.

(4) The Napierian base, e, is distinctly the principal quantity. Its multiplication by m changes it by only about 0.1% (0.001) at the most. E is next in importance. For the earth (carried to three decimal places) the values are as follows: $e = 2.718 \ldots$ $E = 0.017$

$(e/1.98)^n$ will give a better progression law for present distances than many that have been published.

(5) Saturn is distinctly out of place. The schemes of a few other writers also show this.

Please note that no claim is made that the scheme just discussed is a planetary progression law. Two known variables have to be used to get the close values. It is simply a formula. Perhaps no simple formula without variables will completely take care of present distances.

A few questions arise. Why does the formula, without the introduction of arbitrary constants, give results so close to present day values? Why are the results in terms of Mercury's distance as unity? Why does one half the Napierian base figure so prominently? If the planetary masses were all so small as to be neglected and if the eccentricities vanished to zero or were very large, our formula would be stripped down to $(e/2)^n = d$. These would be positions on the true logarithmic spiral, $(e/2)^\theta = d$. Is it unreasonable to wonder if this would then give results so accurate as easily to be recognized as the true planetary progression law?

J. Hugh Pruett.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editors may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Planetary and Electron Distances

I.

1. In Volume 35 (1927), p. 327, of POPULAR ASTRONOMY, Soh has shown that the mean distances of the planets from the sun are proportional to the square of the planet's ordinal number in the following series:*

	Ordinal Number	Distance		Ordinal Number	Distance
Mercury	3	$9 \times K$	Saturn	15	$225 \times K$
Venus	4	$16 \times K$	Uranus	21	$441 \times K$
Earth	5	$25 \times K$	Neptune	26	$676 \times K$
Mars	6	$36 \times K$	Pluto	30	$900 \times K$
Jupiter	11	$121 \times K$			

This fact is so surprising that it should not be believed to be accidental. In order to find a possible reason, I will go back to the possible circumstances at the time of the formation of the planets.

According to Jean's theory, the planets were generated in consequence of an enormous tide of the sun, which a large star, appearing in its near neighborhood, produced. This tide extended in one direction like a huge arm and consisted of masses of gas. This gas-arm became more and more dense, and finally broke in pieces: the planets.

But I assume in this theory, that the masses of gas, becoming more and more dense in an absolutely regular manner, had to break in pieces of *equal length* and had to have the *same velocity* (v). And so it has come about that the sun-distances (d) of the planets at that moment were proportional to their ordinal number (n);

$$d = n \times A \qquad (1)$$

where (A) is a constant factor.

From this fact and from Kepler's law it follows that the length of the orbit's great axis (a) must be proportional to the *square* of the planet's ordinal number. The planets have to satisfy the equation:

Centrifugal Power $= m \times c^2/a =$ Force of Gravity $= k \times M \times m/a^2$

Therefore $a \times c^2 = k \times M$

and $a \times c = \sqrt{(k \times M \times a)}$

or $a \times c = B\sqrt{a} \qquad (2)$

where $B = \sqrt{(k \times M)} =$ constant factor

$k =$ factor of gravity

$M =$ mass of the sun

$m =$ mass of the planet

$c =$ mean velocity

$a =$ mean distance of the planet from the sun

$2a =$ length of the major axis

*I have found this series independently of Soh and communicated it on April 11, 1934, to the Imperial Academy of Science in Vienna. But the Academy showed me the publication of Soh, which I had not yet known at that time. Only later I found the above following reasons which can explain this series.

Further, according to the second law of Kepler, if (r) is the sun-distance and (u) the velocity of the planet in any point of its orbit:

$$r \times u = a \times c,$$

therefore also for the sun-distance (d) and velocity (v), at the moment when the planets are beginning their orbit:

$$d \times v = a \times c,$$

or, according to equation (2):

$$d \times v = B\sqrt{a},$$

and according to equation (1):

$$A \times n \times v = B\sqrt{a}$$

or

$$n \times v = C\sqrt{a} \qquad (3)$$

$$(C = B/A = \text{constant}).$$

For the planets having the ordinal number: 1; 2; 3; . . . n; having the major axis: a_1; a_2; a_3; . . . a_n; and all of them having (as supposed above) the same velocity (v), it results from the equation (3):

$$1 \times v = C\sqrt{a_1}$$
$$2 \times v = C\sqrt{a_2}$$
$$3 \times v = C\sqrt{a_3}$$
$$\ldots\ldots\ldots\ldots$$
$$n \times v = C\sqrt{a_n}$$

or $$\sqrt{a_1} : \sqrt{a_2} : \sqrt{a_3} : \ldots : \sqrt{a_n} = 1 : 2 : 3 : \ldots : n$$

or $$a_1 : a_2 : a_3 : \ldots : a_n = 1 : 4 : 9 : \ldots : n$$

and

$$a_1 = 1 \times K$$
$$a_2 = 4 \times K$$
$$a_3 = 9 \times K$$
$$\ldots\ldots\ldots$$
$$a_n = n \times K \qquad (K = \text{constant})$$

which was to be demonstrated.

2. According to Jeans' theory, the greatest planets must be situated in the middle of the series, because the large star tore from the sun the greatest mass of gas at the moment it was nearest to it. Really the sun-distances of the greatest planets Jupiter ($a = 121 \times K$) and Saturn ($a = 225 \times K$) are far from being half the sun-distance of Pluto ($a = 900 \times K$). But if you observe that the distances at the moment of the planets' generation were proportional to the planets' ordinal numbers, such as is described above, you will find the distance of Saturn ($d = 15 \times A$) being exactly half the distance of Pluto ($d = 30 \times A$), and Jupiter ($d = 11 \times A$) near enough in a position required by Jeans. This is indeed a beautiful confirmation of Jeans' theory.

II.

1. It has been above supposed that the planets' distances from the sun, at the moment of their generation, were proportional to their ordinal numbers, and that this is the reason for the fact that the major axes of the planets' orbits are now proportional to the *squares* of these ordinal numbers. If this supposition is granted concerning the *planets'* orbits, then one will easily grant that there might have been similar reasons which effected that also the major axes of the orbits of the *electrons* have become proportional to the squares of the electrons' ordinal numbers.

To find these reasons, I will also, concerning the atoms, go back to the act generating them. According to Bohr's theory, giving an idea of how to build up

an atom, the nucleus catches the electrons and attaches them to itself. But I assume in this theory that the nucleus may not be able to attach the electrons when they are still in a chaotic state, but only after having arranged themselves, under the influence of their mutual forces, into a state of relative equilibrium of the electrons to one another.

Let, for instance, the electrons arrange themselves around a nucleus on the surfaces of equidistant, concentric spheres having all the same density of electrons, that means the same number of electrons on each square inch. In this case the force of the electric field would be the same at each point of all surfaces, and therefore, the electrons would remain in mutual equilibrium, subjected only to the attractive power exercised by the nucleus. And, only as soon as this relative equilibrium is reached, is the nucleus able to attach the electrons, which now, under the influence of its attractive power, can begin their orbits.

We now give ordinal numbers to the spheres and give every electron the same ordinal number as the sphere to which it belongs. As the spheres are equidistant, their radii, and therefore also the electrons' distances from the nucleus must be proportional to the electrons' ordinal numbers, and this at the moment when the electrons begin their orbits. And this is why, following from Kepler's law as above explained concerning the planets, also the major axes of the electrons' orbits have to be proportional to the squares of their ordinal numbers.

2. Of course, there are several electrons having orbits of equal major axes, *viz.* as many electrons as had been placed on the same surface and which, therefore, all have the same ordinal number. And as we have supposed all surfaces to have the same density of electrons, the number of such electrons, which have the same ordinal number, increases as the surface to which they belong, i.e., as the squares of the ordinal numbers.

Let us now suppose that on the first sphere there can be placed only two electrons, and that for the following reason: The two electrons, next to the nucleus and surrounding it like a conductor charged with electricity, diminish the nucleus' charge of opposite electricity. And as the diminished charge of the nucleus is not able to attract a third electron still with the same force as the first and second ones, a third cannot remain on the same (first) sphere.

So it comes about that there can exist indeed only 2 electrons having the ordinal number "1." But having the ordinal number "2," there can exist $2 \times 2^2 = 8$ electrons; having the ordinal number "3," there can exist $2 \times 3^2 = 18$ electrons; having the ordinal number "4," there can exist $2 \times 4^2 = 32$ electrons, and so on, finally having the ordinal number "n" there can exist $2 \times n^2$ electrons.

This law is derived from the above mentioned fact, that the number of those electrons, which have the same ordinal number, increases as the squares of the ordinal numbers.

Of course, these quantities of electrons:

$$2 \quad 8 \quad 18 \quad 32 \quad 50 \quad \ldots \quad 2 \times n^2$$

are those prescribed by the law of Pauli.

3. Only with the aid of the "Quanten-Theory" and its "Wirkungsquantum" has Bohr derived the fact, that the major axes of the electrons' orbits have to be proportional to the square of their ordinal numbers. But having derived this fact from other reasons, one is now able to derive by an inverse manner the fact of a "Wirkungsquantum."

IVAN DORY.

Vienna, Germany, IV Faulmangasse 6.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

First Known Eclipsing Variable in Magellanic Clouds: What is probably the first known eclipsing star in the Magellanic Clouds has recently been measured by Miss Virginia McKibben at the Harvard Observatory. The star, which was discovered many years ago by Miss Leavitt and bears the number H.V. 2425, is in the Large Cloud of Magellan. Observations covering approximately forty years have revealed a period of 5.8686217 days. The variable is of magnitude 15.7 at maximum, and has a range of about 0.9 magnitude. The range of the secondary minimum is less than 0.4 magnitude. The light curve has rounded maxima, and resembles that of β Lyrae.

It is barely possible that the star is a superposed member of the Milky Way. On the assumption of an absolute magnitude of +1 at maximum, the modulus of 14.7 would lead to a distance of 8.7 kiloparsecs. At the galactic latitude of —33° this gives a distance of over fifteen thousand light years from the galactic plane. Such a distance is very unlikely for eclipsing stars in the Milky Way, and the probability is therefore high that the star is really a member of the neighboring galaxy and at maximum is a bright giant, with absolute magnitude —1.4.

Early Observations of Gamma Cassiopeiae: In an article by Dr. Felix de Roy in *L'Astronomie* for November, 1936, is a discussion of the measures of γ Cassiopeiae as made by E. C. Pickering and his collaborators during the compilation of the Harvard photometric catalogues. The observations covered the years 1879 to 1901, and gave a mean magnitude of 2.25, representing the arithmetic mean of all the determinations made with the meridian photometer. Some 230 individual measures with the dates are included, so that it is possible to study the observations in detail. As γ Cassiopeiae was one of a hundred circumpolar stars used as standards, the measures during each opposition necessarily cover only a few months, when the star was at either upper or lower culmination.

De Roy shows that although the mean magnitudes for different oppositions do not differ greatly, yet the observed variation of between $2^M.1$ and $2^M.4$ cannot be entirely due to accidental error. The maximum brightness of 2.1 was attained in 1894 from a mean of 13 measures; the minimum of 2.4 in 1879 and 1885, from 5 and 17 measures, respectively. The months of November and December, 1894, gave strong evidence of an increase in brightness from 2.3 to 1.7, and then a decrease to 2.3. De Roy also discusses the early historical estimates of magnitude for γ Cassiopeiae from the time of Hipparchus, 127 B.C., down to C. Flammarion in 1880. These observations are grouped around a general mean of 2.3, ranging between 2.7 and 1.9.

One is thus led to believe that the star had undergone variations in light prior to 1936, even if not to the extent indicated in various star catalogues.

Visual Observations of the Brightness of Comets: C. Tshernov, in the *Tadjik Observatory Circular* for December, 1937, publishes some interesting observations on the magnitude of Finsler's Comet during the month of August, 1937. Comparison star values were taken from *Harvard Annals*, 50, and the range of bright-

ness obtained was from 4.9 on August 3, to 3.7 on August 11, decreasing again to 5.8 on August 31. Similar observations on Peltier's Comet 1936*a* were made by Sloviev from May 29 to August 2, 1936, and indicate a steady increase in magnitude from 9.5 on May 29, to 3.7 on August 2. Such observations, difficult though they may be, have a decided value in connection with the study of comets, and should be extended to other bright comets as they are discovered.

The Double-Period Variable Star, V Hydrae: From an examination of the current plotting of the observations of V Hydrae, 1046*o*, it seems as if this very red, N-type variable star were about to begin its 17 year-period drop to a deep minimum. Observations in 1936 indicated a magnitude of about 7.0, those for 1937 of about 7.5, and at the present time the magnitude is between 8.0 and 8.5. The star, because of its red color, is very difficult to observe by visual methods. Deep minima, magnitude 12, were observed in 1908 and 1925, with a similar minimum indicated in 1891. The next deep minimum is due to occur in 1942-43. The short-period variation is of the order of 550 days; the long-period, of 6200 days, or 17 years. The maximal range is from magnitude 6 to 12, with an amplitude of variation amounting to one or two magnitudes during the shorter period. The star requires special attention during the next few years.

The Variation of Eros: As predicted, the variation of the light of Eros during the opposition just passed was well marked and of varying amplitude. Miss Margaret Harwood, Director of the Maria Mitchell Observatory, has secured a series of exposures from August, 1937, into April of this year and reports preliminary results as follows:

Dates	Amplitude M	Dates	Amplitude M
October 30	0.3	February 1, 2	1.3
November 3	0.5	February 4, 8, 21	1.0
November 25	0.8	March 6	1.0
December 5	1.0	March 22, 28	0.5
January 5, 8, 20	1.1	April 3, 5	0.5

The apparent range in magnitude of the asteroid during these months was between $9^{M}.5$ and $12^{M}.5$, photographically. The double period of $0^{d}.2195942$, assigned in 1931, is apparently still being well maintained. The complete results of this investigation by Miss Harwood will be printed later.

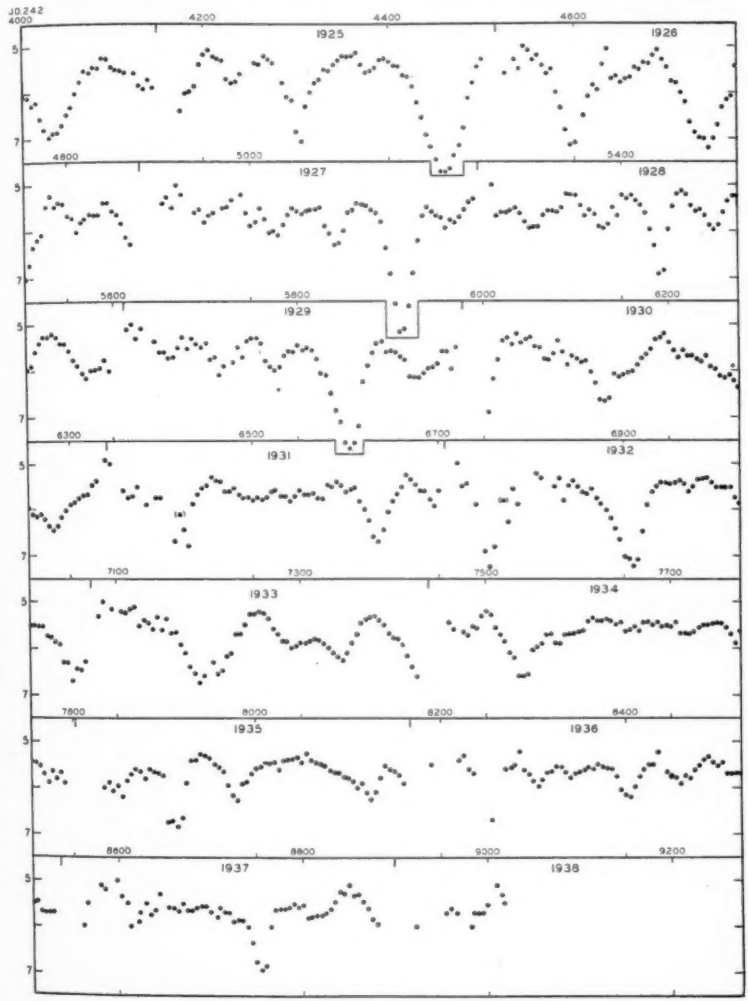
The Eclipsing Variable SV Tauri: An excellent photometrically observed light curve of the hitherto little observed eclipsing star, SV Tauri, has been secured by Dr. Lassovszky of the Astrophysical Observatory of Budapest. Some 1260 measures were made on 100 nights during the years 1930 to 1936. The light curve shows a principal minimum with an amplitude of 1.09 magnitudes and a secondary minimum, somewhat displaced, of 0.15 magnitude. Dr. Lassovszky used the observed light curve to derive new elements for the system; no abnormal features are apparent. Some of the results, computed on the basis of uniform darkening at the limb, follow:

Period	$2^{d}.1669028$
Phase of secondary minimum	$-0.0185+\frac{1}{2}P$
Duration eclipse	0.472
Duration totality	0.000
Radius of faint companion	0.355
Radius of bright companion	0.291
Density of faint companion	$0.032\odot$
Density of bright companion	$0.058\odot$
Luminosity of large companion	0.232

Luminosity of small companion.....	0.767
Mass of large companion	11.295
Mass of small companion	9.997

The observed light curve shows a remarkable agreement with the computed light curve, the residual in no case exceeding 0.05 magnitude.

The Semi-regular Variable R Scuti: Among those stars which have been



LIGHT CURVE OF R SCUTI, 1924-38
14,000 observations grouped in 5-day means

favorites with observers for many years is the semi-regular variable, R Scuti, situated not far from the cluster Messier 11. It was carefully observed by Arglander, Schoenfeld, Schmidt, and others a century ago, and is still on the observing lists of variable star associations. The star has been the subject of many discussions, especially by Gerasimovič ten years ago, who investigated its period from data covering more than a century. He concluded that the double period was subject to a progressive change: from a length of 139 days at the end of the eighteenth century to 146 days in the 1920's. Although this progressive change was not perfectly uniform, being subject to considerable irregularity, he felt certain that the period was gradually lengthening. This conclusion has not been borne out by the observations of the past ten years, during which the period appears to have averaged less than 145 days. The star is certainly to be considered as semi-regular; from recent observations, it might almost be called irregular. While a single period of approximately 70 days does persist, yet it is found that the intervals between minima, which are more sharply defined than the maxima, vary between 37 and 100 days. In general, the shallow and deep minima alternate; this order, however, may be suddenly and frequently broken, and when one expects a deep minimum to occur one finds instead no minimum indicated but an even brighter maximum than usual. Such a condition existed in 1930. Frequently, instead of an alternation of shallow and deep minima, a period of inactivity intervenes such as was observed in 1934.

There is a marked difference in the depth of the so-called deep minima. On occasion, the star barely fades to the seventh magnitude; at other times it decreases to below the eighth, as in 1925, 1927, and 1929. Some maxima barely attain magnitude 5.7, while at times the star is noticed to be as bright as 5.0—perhaps even somewhat brighter.

While there appears to be strong evidence for a 70 or 140 day cycle in the period, we cannot say that either value represents the period of variation. There are undoubtedly other factors which tend to complicate the variation, thus producing marked differences in form of curve at different maxima and minima. The star should be studied more closely from a spectroscopic viewpoint, and spectral changes correlated with light changes; in order to prove the existence of seemingly small variations in light at maximum, photoelectric measures are desirable. The study of the changes in period and light curve of R Scuti should be an interesting and valuable subject for a doctorate thesis.

The light curve here shown represents the observations as grouped under 5-day means for the years 1924 to 1938, and many of the irregularities and vagaries above mentioned are clearly indicated.

The Brown University Meeting of the A.A.V.S.O.: The 27th Annual Spring Meeting of the A.A.V.S.O. was held at Brown University in Providence, Rhode Island, on May 27 and 28. On Friday evening the Association was the guest of the Sky Scrapers Inc. of Providence, who were holding their sixth annual dinner and meeting, with Professor Carl L. Stearns of the Van Vleck Observatory, Middletown, Connecticut, as guest speaker. Professor Stearns lectured on "Comets," reviewing the early history of the discovery and observations of these visitors to our gaze, as well as describing in detail many of the facts, expected and unexpected, which they present. The lecture was all inclusive and well illustrated with slides.

The Council of the A.A.V.S.O. met at the Ladd Observatory and, among other things, elected twenty persons to annual membership, one to life membership,

and one as a Patron, the last mentioned being Mr. George C. Waldo, Jr., of Fairfield, Connecticut. Appropriate action was taken on those the notice of whose death had been received since the last meeting. These included: Charles E. Barns, Morgan Hill, California, Patron; George E. Hale, Mount Wilson, California, Honorary Member and Patron; Vera A. Gushee, Ludlow, Massachusetts; Leon Barritt, Brooklyn, New York.

The Council aproved the suggestion whereby some of the duplicate books in the A.A.V.S.O. McAteer Library might be offered for sale to members and others, in order to raise funds for the binding and rebinding of some of the valuable books in the library. There is an exceedingly large number of such duplicates, covering many old and new valuable books. The erection of the William Tyler Olcott placque at the A.A.V.S.O. headquarters, above which hangs his framed photograph, was announced at this meeting.

IN MEMORY OF
WILLIAM TYLER OLCOTT
CO-FOUNDER OF THE AMERICAN ASSOCIATION
OF VARIABLE STAR OBSERVERS
ATTESTING HIS FAITHFUL SERVICE AS
SECRETARY FOR A QUARTER OF A CENTURY
1911 - 1936

The regular business meeting of the Association was held at 10:00 o'clock on Saturday morning when Vice President Adams extended the greetings of the University and welcomed the Association, "The largest body of variable star observers ever to meet here," to Brown University. Dr. Adams recalled to our minds that astronomy, from the teaching standpoint at least, had been an important part in the curricula of the college since 1838, and that the University had possessed a telescope, small though it was, since the foundation of the college in 1764.

Dr. Alice H. Farnsworth was appointed the newly elected chairman of the Publications Committee, the other members being the Secretary and the Recorder.

The following persons were nominated, with the approval of the Council, for the Council slate to be voted upon at the October meeting: Dirk W. Brouwer of Yale Observatory; Leo J. Scanlon of Pittsburgh, Pennsylvania; Joseph W. Meek of Tucson, Arizona; and Joseph S. Woods of Baltimore, Maryland.

The members present gave their hearty endorsement to the suggestion of Dr. C. W. Gartlein of Cornell University, that the A.A.V.S.O. should actively participate in an auroral observing program.

Some fifty members were in attendance at the various sessions, the most distant representative being Claude B. Carpenter from Wayne, Michigan. Following the reports of officers and committees, the bestowal of the Fifth Merit Award of the A.A.V.S.O. to Mr. David B. Pickering—in absentia,—there came the presentation of papers as follows:

Astronomical Hobbies and Oddities, L. L. Doolittle; this paper depicts some of the "believe it or not" facts in connection with the stars within and without our own galaxy.

Synthetic Mirrors, R. W. Seely; dealing with the possibility of using metal mirrors of small diameter for variable star observing.

A New Variable Star, (—32°15317), S. Gaposchkin; describing the observed facts on a recently discovered, bright, eclipsing variable.

The Published Times of the Minima of Algol, J. S. Andrews; pointing out the discrepancies found in the published lists of the minima of this star.

Observing Amphitrite, D. W. Rosebrugh; showing the methods of observation and the results he obtained on this particular asteroid.

Use of Variable Stars to Measure Distances in the Milky Way, Harlow Shapley; this paper dealt at length with an investigation of Cepheids, having periods less than a day, on the outer confines of our own galaxy with the conclusion that there is no evidence of intergalactic Cepheids, but indicating that a few had been found in Coma and Virgo of the order of 70,000 to 120,000 light years distant. SX and SV Comae and BE Virginis are considered the most distant Cepheids yet found.

The A.A.V.S.O. and its Progress, Leon Campbell; this paper—actually read following the banquet—described the present and future plans for enlarging the scope of the work of the Association to include celestial photography, auroral observations, the extension of the regular visual program to include some of the I.A.U. "100 Important Variables," and those stars which, from a recently proposed photographic program at Harvard, may reveal results requiring additional investigation.

At the afternoon session Dr. J. B. Focke, of the Physics Department of Brown University, demonstrated very clearly and successfully the actual aluminizing of a mirror; then followed an inspection of the Ladd Observatory with particular attention to the 12-inch refractor and the Schmidt camera, so successfully used by Dr. Smiley for the solar eclipse of 1937, and of the Seagrave Memorial Observatory at North Scituate, now an intergral part of the Sky Scrapers Inc., with its splendid 8-inch Clark refractor formerly owned and used by F. E. Seagrave for early pioneer work on varaible stars.

Tea was served at the home of Mr. and Mrs. L. J. Boss of North Scituate, well known members of the Sky Scrapers and the A.A.V.S.O.

The usual banquet was held at the Hearthstone "Barn" in East Providence with Dr. Alice H. Farnsworth acting as toastmistress. The meeting adjourned at 10:30 o'clock to meet again in October at Harvard. Hearty thanks and appreciation were extended to all those who had made the meeting such a fine occasion, especially to Dr. and Mrs. Smiley, on whose shoulders rested most of the burden of the details.

New Observers and Observations: Recent additions to the A.A.V.S.O. ranks are Messrs. Day, Kretschmer, Locke, and Vinson, working under the guidance of Dr. R. C. Huffer at Beloit College, Wisconsin; J. A. Weber, S.J., Woodstock College, Maryland; M. J. Irland, Dearborn, Michigan; C. N. Forster, Toronto, Canada; and Messrs. L. J. Freeman and L. Heinemann of Poughkeepsie, New York, under the direction of Mr. D. W. Rosebrugh.

Observer	Var.	Est.	Observer	Var.	Est.
Ahnert	38	200	Chandra	208	688
Baldwin	62	100	Chartier	43	69
Bappu	27	80	Cousins	21	90
Blunck	6	11	Dafter	10	24
Bouton	54	74	Day	4	4
Brocchi	34	117	Diedrich	8	35
Buckstaff	4	7	Ellis	23	32
Callum	57	83	Ensor	60	226
Cameron	1	1	Escalante	40	88
Carpenter	32	32	Evans	27	38

Observer	Var.	Est.	Observer	Var.	Est.
Fairbanks	5	5	Loreta	140	289
Fernald	2	10	MacCalla	5	6
Forster	3	16	McLeod	10	14
Franklin	14	14	McNabb	3	26
Freeman	2	2	Meek	26	107
Gomi	2	36	Millard	33	59
Gregory	85	96	Palo	2	2
Halbach	1	1	Peltier	179	227
Hartmann	127	212	Pilnick	6	8
Heinemann	1	1	Plueddemann	5	6
Heinmiller	5	5	Purdy	9	12
Herbig	97	274	Rademacher	6	17
Hiett	33	73	Recinsky	9	27
Hildom	25	59	Rosebrugh	21	50
Hoffstetter	6	8	de Roy	13	56
Holt	72	197	Russell	18	23
Houghton	69	194	Ryder	11	11
Houton	95	245	Seauvageau	8	11
Howarth	12	16	Seely	7	26
Huffer	8	9	Shafer	4	9
Irland	7	7	Sill	49	78
Jones, E. H.	108	470	Smith, F. P.	24	30
Kearons	30	75	Smith, F. W.	1	1
Kelly	8	13	Smith, J. R.	6	6
Keuziak	3	3	Treadwell	16	48
Kirkpatrick	48	175	Vinson	2	2
de Kock	50	162	Watson	19	61
Kotsakis	26	46	Webb	40	41
Kozawa	9	21	Weber	11	11
Kretschmer	1	1	Woods	16	44
La Fon	24	36	Yamasaki	23	23
Locke	4	4			

Correction: On page 290, May, 1938, of these notes for *The Eclipsing Variable RZ Persei* read *The Eclipsing Variable RT Persei*, and later in the same line for *RZ* read *RT*.

May 29, 1938.

General Notes

Professor Charles Fabry delivered the George Darwin Lecture at the Ordinary Meeting of the Royal Astronomical Society on May 13, using as his subject, "Interstellar Space."

Dr. Frederick Slocum, professor of astronomy and director of the Van Vleck Observatory, Wesleyan University, will give the graduate convocation address at Brown University on the occasion of the semi-centennial anniversary of the establishment of graduate work on June 18. He will speak on "Intellectual Curiosity." (*Science*, April 29, 1938.)

Professor Pio Emanuelli of the Royal University of Rome has been nominated as a member of the International Academy of the History of Science. At present there are only two astronomers who are members of this academy, the other being Professor E. Zinner, director of the Remeis Observatory in Bamberg, Germany.

Professor Anders Severin Donner, for many years Director of the Helsingfors Observatory, died on April 15 of this year, aged eighty-four years. He was greatly interested in the development of photographic methods. In 1887 he attended the first Astrographic Congress at Paris and was the last survivor of this memorable group.

Professor Leuschner Honored.—The degree of doctor of laws was conferred on Professor Armin Otto Leuschner, Chairman of the Berkeley Astronomical Department and Director of the Students' Observatory, by the University of California on the occasion of its Seventy-fifth Commencement Day Exercises, May 21. The degree was presented by President Sproul, who made the following citation: "Stimulating teacher, resourceful scholar, able administrator; inspirer of many of America's leading astronomers; authority on minor planets and inventor of effective methods for computing cometary orbits; staunch champion of high standards in education; loyal and unselfish servant of the University for a full half century."

On the occasion of his retirement from active service which takes place on June 30 of this year, the Regents of the University conferred on Professor Leuschner the title of Professor of Astronomy and Director of the Students' Observatory, Emeritus. Professor Leuschner has been connected with the University of California for fifty years, the first two of which were spent at the Lick Observatory as a graduate student and voluntary assistant.

Asteroid Planckia.—On the eightieth birthday of Professor Max Planck announcement was made that an asteroid, discovered by Professor Max Wolf in 1927, later assigned the number 1069, had been given the name *Planckia.*

The Rittenhouse Astronomical Society, of Philadelphia, held a meeting of the Society on Friday, May 13, in the Hall of The Franklin Institute. The feature of the program was an illustrated address by Dr. Forest Ray Moulton, permanent secretary, The American Association for the Advancement of Science, the subject being "Cataclysms."

Astronomical Meetings of Section D at Ottawa

In connection with the meetings of the American Association for the Advancement of Science at Ottawa, the section on astronomy (D) will hold joint sessions with the Royal Astronomical Society of Canada at the Dominion Observatory June 28, 29, and 30.

Contributed papers will be presented on Tuesday and Wednesday mornings. On Thursday morning a symposium on atmospheric ozone will be held, with Dr. Brian O'Brien of the University of Rochester in charge.

Dr. B. Haurwitz of the Department of Transport of the Meteorological Service of Canada will review the general problem of ozone as a constituent of the atmosphere. Dr. E. H. Gowan of Edmonton will discuss ozonosphere temperatures under radiation equilibrium. Meteorological relations will be presented by Dr. Chaim Pekeris of the Massachusetts Institute of Technology. Dr. O'Brien will discuss the methods of measurement of atmospheric ozone from the distribution of solar radiation in the ultra-violet.

HARLAN T. STETSON, *Secretary,* Section D.

The Committee on Science and its Social Relations

In May, 1937, the International Council of Scientific Unions decided to establish a committee to be called "The Committee on Science and its Social Relations" (C.S.S.R.), the purpose of which is "to consider the progress, interconnections, and new directions of advance in the mechanical, physical, chemical, and biological sciences, especially in order to survey, at suitable intervals, and to promote thought upon the development of the scientific world picture, and upon the social significance of the applications of science."

Professor F. J. M. Stratton of Cambridge, England, is president of this Committee, Professor S. Chapman of London, England, vice-president, and Professor J. Burgers of Delft, Holland, acts as its secretary. The C.S.S.R. plans to publish by 1940 a report dealing with various aspects of the relations between science and society, and it has now undertaken the task of collecting from various sources material for this report. This basic material is to be gathered from three sources:

1. Correspondents of national academies, representing all or most branches of science in each separate country;
2. Correspondents of international scientific organizations, each representing one branch of science;
3. Individual scientists who may care to communicate to the committee their views on the subjects of the report.

Dr. Bart J. Bok, of Harvard Observatory, Cambridge, Massachusetts, U.S.A., has been appointed as the correspondent for the International Astronomical Union.

The C.S.S.R. requests information on the five following subjects related to Astronomy:

1. Modern views on the structure of the Stellar Universe and the constitution of the stars;*
2. The presentation of astronomical methods, techniques, and results in popular form;
3. The attention given by the general public to serious expositions of modern astronomical work;
4. The part played by amateur astronomy;
5. The importance of international coöperation in astronomy.

The collection of the data for the report on subjects 3 and 4 presents a rather difficult problem. The correspondent has therefore mailed to each of twenty-five representative astronomers of different nationalities a questionnaire dealing with the non-professional aspects of astronomical activity in their respective countries. Included are questions referring to amateur astronomical societies, astronomical museums, planetariums, and schools, and regarding the interest in astronomy shown by the general public.

The C.S.S.R. hopes that it may serve as a clearing house for matters pertaining to the relations between the sciences and society. It is not the only purpose of the present note to acquaint astronomers generally with the aims of the C.S.S.R., but also to request that everyone interested in the project communicate his views to this Committee. Correspondence on points dealing specifically with the public relations of astronomy should preferably be sent to Dr. Bok, but communications of a more general character should be sent directly to Professor J. Burgers (address: van Houtenstraat 1, Delft, Holland).

*The requested information is mainly of a bibliographical nature.

It is well to emphasize that the present survey is intended to cover every part of the world and every country in which there exists an active interest in astronomical progress. Such a world-wide survey of non-professional astronomical activities may serve as a useful guide for further developments of the relations between astronomy and society.

The C.S.S.R. is an international committee whose chief purpose is to act as an exchange bureau for information concerning the public relations of science; its work is to be limited strictly to scientific activity.

Program for the Symposium on Recent Progress in the Interpretation of Molecular Spectra and in the Study of Molecular Spectra in Celestial Objects, June 22 to 25, 1938

The symposium on Physics and Astronomy to be held at the Yerkes Observatory on the dates indicated above was announced and general information concerning it given in the February (1938) issue, page 120, of this magazine. The detailed program is now at hand and is as follows:

June 22, 1938—

2:00 to 4:00 P.M.

Professor John T. Tate
"Ionization and Dissociation Processes in Molecules by Electron Impact"

Dr. G. H. Shortley
"Continuous Spectra"

8:00 to 9:00 P.M. Lecture by Dr. Otto Struve
"The Contours and Intensities of Spectral Lines in Stellar Atmospheres."

June 23—

9:45 to 11:45 A.M.

Professor David M. Dennison
"The Infra-red Spectrum of Water Vapor"

Dr. Arthur Adel
"Spectroscopic Studies of Planetary Atmospheres"

1:30 to 4:00 P.M.

Professor Gerhard Herzberg
"Dissociation, Predissociation, and Recombination of Diatomic Molecules"

Dr. Hans G. Beutler
"Absorption and Fluorescence in Dependence on Pressure and Temperature"

Dr. Karl Wurm
"The Interpretation of the Spectra of Comets and their Forms"

8:00 P.M. Lecture by Dr. G. P. Kuiper
"The Mass Luminosity Relation and White Dwarf Stars"

June 24—

9:45 to 11:45 A.M.—

Professor Robert S. Mulliken
"Ultra-violet Spectra of Molecules"

Professor Gerhard Herzberg
"Forbidden Transitions in Diatomic Molecules"

2:00 to 4:00 P.M.

Professor N. T. Bobrovnikoff
"Molecular Bands in Stellar Spectra"

Dr. W. W. Morgan
"Molecular Bands as Indicators of Stellar Temperatures and Luminosities"

June 25—
9:45 to 11:45 A.M.
Dr. Rupert Wildt
"Electron Affinity in Astrophysics"
Drs. Struve and Wurm
"The Spectrum of the Earth's Atmosphere"

The scientific sessions will take place at the Yerkes Observatory, Williams Bay, Wisconsin. The headquarters at the time of the symposium will be at College Camp which adjoins the grounds of the Yerkes Observatory. The rate for room and board will be $12.75 per person for two persons in a room, for four full days. It is suggested that the members of the symposium plan to have lunch at the main dining room of College Camp on Wednesday, June 22, in which case the rate would apply until Sunday morning after breakfast. A somewhat higher rate will apply for rooms occupied by one person. Reservations for room and board at College Camp should be made as early as is possible, and certainly not later than Monday, June 13. These reservations may be made by writing to the Yerkes Observatory, Williams Bay, Wisconsin. Accommodations at a slightly lower rate can probably be secured in boarding houses and private residences in the village of Williams Bay.

All astronomers and physicists are cordially invited to attend the symposium and to participate in the scientific discussions. Graduate students attending the summer school of the University of Chicago in the Department of Physics or at the Yerkes Observatory are also invited. Registrations for the summer school should be made in the usual way through the offices of the University of Chicago.

Yerkes Observatory.

Book Reviews

The Origin of Life, by A. I. Oparin (translated with annotations by Sergius Morgulis). 270 pages. The Macmillan Company, New York, 1938.

To find a book written by a biochemist reviewed in a journal devoted to astronomy may seem at first somewhat surprising. We must recall, however, that in astronomy we do our best to account for the formation of the earth and the rest of the solar system by means of such theories as those of Jeans and Jeffreys, Chamberlin and Moulton, and Lyttleton. Then, when asked about the appearance and evolution of life on the earth, we say, glibly, "That's the biologist's problem," so we should stop for at least a moment to see how well the biologist and the chemist have handled the part of the problem we have left to them.

The book under review appears to me, with my negligible knowledge of chemistry and biology, to be quite scholarly and, up to a certain point, quite convincing. I must admit that it is the first time I have read anything of the kind. Oparin is the Associate Director of the Biochemical Institute of the U.S.S.R. Academy of Science; the apparently capable translator is professor of biochemistry in the College of Medicine of the University of Nebraska.

Chapters I, II, and III (63 pages in all) are historical. The first deals with the struggles of the early scientists to learn the origin of the micro- and macroscopic forms of life which seemed to be spontaneously generated from decaying organic matter. These struggles culminated in the work of Pasteur, and by this same work, as is pointed out early in the second chapter, any idea of the continuity of life (endlessness in the past, and perhaps in the future) was negated. To state

that life has always existed, along within organic matter, is to solve the problem by denying its existence. In this connection, however, is treated the possibility that life might have been transmitted to the earth by means of spores, perhaps driven from other systems or other planets of this system by radiation pressure, later attaching themselves to meteoroidal bodies, which fell to earth. This theory of *panspermia* is dismissed finally with the statement that either the intense ultraviolet radiation or cosmic radiation would have killed all spores, in their voyaging outside a protecting atmosphere. Chapter III deals with such naïve statements as "When the earth cooled off and the existence of organic life became possible, it appeared as the result of an unknown combination of matter and energy." Oparin's point here is that anything as complicated as the simplest organism can not reasonably be expected to have happened all at once, at the proper tick of the cosmic clock.

The first 25 pages of Chapter IV contain a good summary of spectral classification and planetary atmospheres and origin. Incidentally, the author dismisses the possibility that spores have been found in meteorites; the hydrocarbons therein contained must have had a primary origin (i.e., without any relation to organic life). Many will remember that Russell, in his recent *The Solar System and its Origin*, suggests that the presence of ammonia and methane in the atmospheres of the giant planets poses an interesting question to the chemist, inasmuch as on the earth these materials are the products of organic matter. Oparin has demonstrated fairly well that the primary forms of carbon were the element and compounds with nitrogen (cyanogen) and hydrogen; similarly nitrogen first appeared on the earth in its reduced state in the form of ammonia. Neither free oxygen nor carbon dioxide existed originally on the earth; both are by-products of organic matter; it is not that life came into existence because there was free oxygen for it to begin on, but that free oxygen came into existence because of the presence of life!

Chapter V, "Origin of Organic Substances: Primary Proteins," discusses the methods by which the primary substances described in the previous sections could have formed proteins, but "protein is by no means living matter, but hidden in its chemical structure is the capacity for further organic evolution which, under certain conditions, may lead to the origin of living things." The "Origin of Primary Colloidal Systems" must next be discussed; then primary organisms could come into existence. With Chapter VII, then, the topic indicated in the title of the book has been completely discussed; however, another chapter of 50 pages is devoted to "Further Evolution of Primary Organisms." The book closes with a brief chapter of summary, in which the concluding sentence is "The artificial building of synthesis of living things is a very remote, but not an unattainable goal."

Certainly the first six chapters seem convincing. The origin of complicated molecules, and their separation from the primeval water, are topics well presented. The change from a lifeless molecule to a living organism is too abrupt for this one reader. I have already confessed to little knowledge of biochemistry, but I feel unable to bridge the gap, try as hard as I may; I cannot help feeling that there is something more to life than a complex molecule capable of growing. Such silly sentiment should not stand in the way of adequate proof, of course.

I enjoyed the book, as I am sure every astronomer will. In it there appears a unification of several branches of science, to the end of attempting to solve the riddle implied in the title. My own reaction can be summed up in a few words: I wonder how life *did* come about?

ROY K. MARSHALL.

Wilson College, Chambersburg, Pennsylvania.

Early American Observatories, by Willis I. Milham.

One hundred years constitute a negligible period of time when the astronomer is considering cosmic processes. But when he is thinking of the development of astronomical study in America a period of one hundred years becomes interesting and impressive. Last year the Hopkins Observatory at Williams College, Williamstown, Massachusetts, attained its centenary. This fact prompted the director, Professor Willis I. Milham, to prepare a record of the first hundred years of this observatory, and in doing so he extended his investigation to include other early American observatories as well. The result of this undertaking is a neatly-bound volume of three separate pamphlets including more than one hundred pages. The separate pamphlets are entitled, "Early American Observatories," "Astronomy in Williams College," and "Meteorology in Williams College." The pamphlets are well illustrated and contain extensive bibliographies. The volume constitutes a valuable addition to history of astronomy in America. It may be obtained from McClelland Press, Williamstown, Massachusetts, for one dollar.

Our Starland, by C. C. Wylie. (Lyons & Carnahan, Chicago. 378 pages, numerous illustrations, price $0.88.)

Where is the astronomer who has not been asked the question, "What book on astronomy shall I buy for a child?" Professor Wylie has written just the book, so that now, when the question is popped, the astronomer need no longer hesitate, and scratch his head as though worrying about the Einstein problem. *Our Starland* has been written expressly for children, ages 10 to 15, one might infer. The simple facts of astronomy are explained in a non-technical conversational style that should fascinate the youngsters. The book is well illustrated with photographs and drawings, and contains a set of twelve star charts, illustrating the constellation configurations.

An astronomical calendar is appended, listing atronomical events of popular interest, for the years, 1939, 1940, 1941, and 1942. Also appended is a dictionary, giving the pronounciations and definitions of many astronomical terms and other words used in the text.

The book is bound in an attractive cover of sky blue, upon which appears an image of the Great Bear of mythology. One is surprised to find that this little book contains 378 pages. By the time the youngsters finish the book, and one or two others, they will be ready to enroll in Professor Wylie's popular astronomical department at the University of Iowa. R.S.Z.

Correction.—Although the equipment and results of the work of Major Albert W. Stevens were discussed in an article on the Hayden Planetarium-Grace Eclipse Expedition in the August-September (1937) number of POPULAR ASTRONOMY, unfortunately Major Stevens' name was omitted from the list of the personnel of the expedition in that same article. It seems doubtful that any one could be unaware of Major Stevens' membership in the Museum party since the so-called globular corona found upon his photographs has attracted such wide attention, but some record of this omission should be made.

POPULAR ASTRONOMY

CONTENTS

JUNE-JULY, 1938

PROFESSOR WILLIAM H. PICKERING—AN APPRECIATION, E. P. MARTZ, JR. 299

ON THE FALL OF THE GREAT SIBERIAN METEORITE, JUNE 30, 1908, I. S. ASTAPOWITSCH 310

THE CENTRAL-EPOCH METHOD IN PROPER-MOTION WORK, KNUT LUNDMARK 318

Planet Notes for July and August, 1938 320

Asteroid Notes 321

Occultation Predictions for July and August, 1938 323

Comet Notes 324

Comet 1938 *a*,—Periodic Comet 1925 II.

Meteors and Meteorites 325

Meteor notes from the American Meteor Society,—Contributions of the Society for Research on Meteorites: A proposed curriculum in meteoritics for college students; Observations pertaining to the times of meteorite falls; Frequency and distribution of observed meteorite falls (abstract); Recent lists of meteorite falls and statistics concerning meteorites; Delegate appointed to the 1938 I.A.U. meeting at Stockholm, Sweden; Notice concerning abstracts of papers.

Notes from Amateurs 333

The New Haven Amateur Astronomical Society,—Amateur Astronomical Society of Los Angeles,—The Cleveland Astronomical Society,—A power formula for planetary distances.

Communications and Comments 340

Planetary and electron distances.

Variable Stars 343

Variable star notes from the American Association of Variable Star Observers.

General Notes 349

Personal notices,—Asteroid Planckia,—The Rittenhouse Astronomical Society,—Astronomical meetings of Section D at Ottawa,—The Committee on Science and its Social Relations,—Program for the symposium on recent progress in the interpretation of molecular spectra and in the study of molecular spectra in celestial objects, June 22 to 25, 1938.

Book Reviews 353

The Origin of Life,—Early American Observatories,—Our Starland.

Correction 355

The principal articles of this magazine, beginning with Volume 15 (1907), are listed in the INTERNATIONAL INDEX TO PERIODICALS.

Y

299
310
318
320
321
323
324
25
33
40
43
49
3
5